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JUL 80 D E OVERTON, G W SCHLOSSNAGLE F08635-77-C-0254
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AIR FORCE RUNOFF MODEL (AFRUM) USER MANUAL DOCUMENTATION

AD A091717

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AIR FORCE ENGINEERING AND SERVICES CENTER

JULY 1980

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OCTOBER 1978 – JULY 1980

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The Air Force Runoff Model (AFRUM) is a stormwater runoff simulation model designed to predict stormwater flow and quality resulting from real or design storms for small watersheds generally limited to 2,000 acres or less. The principal model inputs are watershed area, land use characteristics, percent forested, percent impervious, and percent denuded. The input will also include either an observed hydrograph or an estimated Soil Conservation Service Curve Number (CN). The model is based upon 410 storms in 36 watersheds. Output is both tabular and graphical and provides the watershed hydrograph, pollutograph,

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20. ABSTRACT (Concluded).

and discussion of model assumptions. This report provides a background of the model, batch user instructions for CDC 6600 computers, and two example problems. The complete software package is provided in the Appendix.

PREFACE

This report contains the Air Force Runoff Model (AFRUM) computer program user instructions and documentation developed during the period October 1978 - July 1980 under contract F08635-77-C-0254 with the University of Tennessee, Knoxville, Tennessee 37916. Captain George W. Schlossnagle managed the project and modified the final product with the assistance of Sgt Mike Siebert to improve the user orientation.

A special thanks is given to the Grissom AFB civil engineers, civil engineering personnel and weather personnel, and the 6th Weather Squadron personnel of Tinker AFB for their excellent support of the project's data collection phase.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

The Air Force Runoff Model (AFRUM) for simulating storm hydrographs and pollutant yields was developed for the U.S. Air Force by the Department of Civil Engineering at the University of Tennessee, Knoxville. The results of three separate but complementary studies had the same fundamental objectives, i.e., to evaluate the effects of specialized land use on stormwater runoff and its associated quality. The three studies were funded by the following three Federal agencies and dealt with the land use indicated:

Federal Agency	Contract-Grant No.	Study Period	Land Use
U.S. Department of Energy	EY-76-S-05-4946	1975-79	Coal Strip Mining
U.S. Department of Interior Office of Water Resources Technology	TENN-A-046	1976-78	Urbanization
U.S. Air Force	F08635-77-C-0254	1975-79	Air Force Bases

AFRUM was developed in the course of analyzing 410 storms observed on 36 watersheds. The storm sample included watersheds

in agricultural, urban, and 100 percent forested land use conditions as well as watersheds undergoing coal strip mining and three watersheds at Grissom AFB, Indiana. AFRUM was extensively modified by the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida to increase the user utility by modification of input and output formats and simplification of internal processes.

SECTION II

OBJECTIVE OF AFRUM

AFRUM was developed for the purpose of simulating stormwater hydrographs from a realtime or design storm rainfall distribution, land use and soil type of the watershed of interest. The watershed is considered to be a lumped system, and the required basin characteristics are percent of watershed that is forested (PF), percent that is impervious (PI), percent in strip mining or denuded (PS), and surface drainage area in square miles (SQMI).

Runoff volume and the associated rainfall excess time distribution are simulated from the input rainfall using the U.S. Soil Conservation Service Curve Number Model (Reference 1). If a runoff hydrograph (stormwater flow rates out of the basin) is read into the program associated with a rainfall hyetograph (rainfall distribution), the program will compute a Curve Number (CN) from this information. Otherwise, a CN must be read into the computer and would be simulated using the procedures specified in Reference 1.

AFRUM makes provision for simulating a unit hydrograph or unit response function (URF), which is convoluted with the rainfall excess hyetograph. This computer program is an adaptation of the simulation phase of the TVA double triangle model reported by Ardis (Reference 2) and later modified by Betson (Reference 3).

A more detailed description of the development of AFRUM has been reported by Overton, Troxler and Crosby (Reference 4), Overton and Crosby (Reference 5), and CEEDO-TR-77-18.

AFRUM also simulates pollutant loads for the associated storm. This simulation is a function of the specified watershed and storm characteristics. Hence, additional parameters are not needed.

SECTION III

HARDWARE AND SOFTWARE REQUIREMENTS

The computer model described in this manual is written in Fortran IV and operates on CDC 6600 computers under the NOSBE operating system. The program requires approximately 56K bytes of usable core capacity and approximately 6CPU seconds to compile and execute. Input is accomplished by a card reader, and the output is accomplished by a 132 position line printer. The plot subroutine, HYPLOT, within this program utilizes a Calcomp Electromechanical Plotter.

1. Input Requirements

AFRUM accepts the following input:

a. Accumulated storm rainfall at equal time intervals, DT.

b. Stormwater discharge flow rates at equal time intervals, DT (this hydrograph may be used if available).

c. Watershed characteristics

(1) Curve Number (CN) which can be estimated using Table 1. If the hydrograph is read in, CN is calculated.

(2) Drainage area in square miles (SQMI).

(3) Percent forest (PF).

TABLE 1. RUNOFF CURVE NUMBERS FOR URBAN AND SUBURBAN AREAS (ANTECEDENT MOISTURE CONDITIONS II AND III; $I_a = 0.2S$)**

		Curve numbers by antecedent moisture conditions							
		II				III			
		Hydrologic Soil*				Hydrologic Soil*			
Zoning Classification	Percent Imperviousness	A	B	C	D	A	B	C	D
Business, industrial, or commercial	75	82	88	90	91	92	95	96	97
Apartment houses	65	78	85	88	90	90	94	95	96
Schools	45	68	78	84	87	84	90	93	95
Urban residential (Lots ± 10,000 ft^2)	40	65	77	83	86	82	89	93	94
Suburban residential (Lots ± 12,000 ft^2)	35	62	76	82	85	80	89	92	94
Suburban residential (Lots ± 17,000 ft^2)	30	60	74	81	84	78	88	92	93
Suburban residential	25	58	72	80	84	77	86	91	93
Parks and cemetaries	20	55	71	79	83	74	86	91	93
Unimproved areas	15	53	70	78	92	73	85	90	92
Lawns	0	45	65	75	80	66	82	88	91
Woods	0	36	60	73	79	-	-	-	-
Meadow (permanent)	0	30	58	71	78	-	-	-	-
Pasture or range	0	49	69	79	84	-	-	-	-

SCS National Engineering Handbook, Section 4, Table 15.1 "Percent of Imperviousness for Various Densities of Urban Occupancy."

*Soils are divided into four hydrologic soils groups: A, B, C, and D. Group A soils have a high infiltration rate even when thoroughly wet. When thoroughly wet, group B soils have a moderate infiltration rate, group C soils have a slow infiltration rate, and group D soils have a very slow infiltration rate. Table 7.1 of Reference 1 lists more than 9,000 soils and their hydrologic group.

**Antecedent Moisture Condition II is an average condition where III has the highest runoff potential. Condition II means soils in the watershed are practically saturated from antecedent rains.

- Data unavailable.

(4) Percent impervious (PI).

(5) Percent strip mined or denuded (PS).

2. Output provided

a. Title banner page.

b. Introduction to the model.

c. Discussion of assumptions made by user.

d. User input data.

e. Adjusted model parameters.

f. Simulated storm hydrograph (graphical and tabular).

g. If read in, observed storm hydrograph (graphical and tabular).

h. Suspended sediment storm load, Mn, Fe, Ca, Mg, SO_4, and total alkalinity storm loads.

SECTION IV

DESCRIPTION OF AFRUM

1. Simulation of Direct Storm Runoff.

This program simulates direct runoff volume and rates using the Curve Number model of the U.S. Soil Conservation Service (Reference 1). All losses except evapotranspiration are lumped into a single initial abstraction. The model correlates the rainfall-direct runoff relations as a function of soil type, land use, and hydrologic condition.

For simple storms (high intensity and of short duration), the retention relative to the potential maximum retention S bears the following relation:

$$\frac{P - Q - I_a}{S} = \frac{Q}{P - I_a} \qquad (1)$$

where P is storm rainfall in inches, Q is the direct storm runoff or effective rainfall in inches, and I_a is the initial abstraction in inches which is a measure of antecedent moisture. Initial abstraction includes surface storage, interception, and infiltration prior to runoff. The concept behind this method is for a given basin soil and land use condition, there is a maximum possible retention as storm rainfall increases, storm runoff will increase as defined by Equation (1). Storm runoff can be solved as follows:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad (2)$$

An empirical relation (Reference 6) for initial abstraction (I_a = 0.2S) is inserted and Equation (2) becomes

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (3)$$

which is the relation used in the SCS method of estimating direct runoff from storm rainfall.

The runoff equation has been placed in graphical form with the main parameter being watershed retention, S, where S was related to the Curve Number, CN, as

$$S = \frac{1000}{CN} -10 \qquad (4)$$

Equations (2) and (4) show the interrelationships between CN, soils, land use, and hydrologic condition for average antecedent moisture conditions and are shown in the SCS Engineering Handbook (Reference 1) and summarized in Table 1.

Although Equation (3) was intended to simulate runoff volume it has been used extensively to simulate runoff rates by allowing P and Q in Equation (3) to represent accumulated storm rainfall and runoff volumes. Hence, incremental rainfall excess rates in each time period $i_e(j)$ are simulated as

$$i_e\,(j) = \frac{Q(j) - Q(j-1)}{DT}$$

where Q(j) and Q(J-1) are accumulated storm runoff volume at times j*DT and (j-1)*DT, respectively, where j is the time increment number.

2. Simulation of Storm Hydrograph

a. Normalized Unit Response Function (NURF)

The Unit Response Function (URF) in AFRUM is based upon Ardis' (Reference 2) quadrilateral function. The URF was coupled with the CN model to form the TVA double triangle model. The shape of the URFs and associated CNs have been optimized on a total of 410 storms in 36 watersheds.

The quadrilateral URF is based on the concept that the initial response from a watershed comes from the riparian areas, and as other areas of the watershed become saturated, they too begin to contribute to runoff in the form of a delayed response. It is assumed that these two responses can be simulated by two separate triangle response functions as shown in Figure 1. When added together, these two triangles form the quadrilateral unit response function.

Symbols used in the figure are:

I = Precipitation excess intensity in inches per hour. Since the volume of input is one basin-inch = 1/DT.

DT = Time interval used in abstracting rainfall and discharge record in hours.

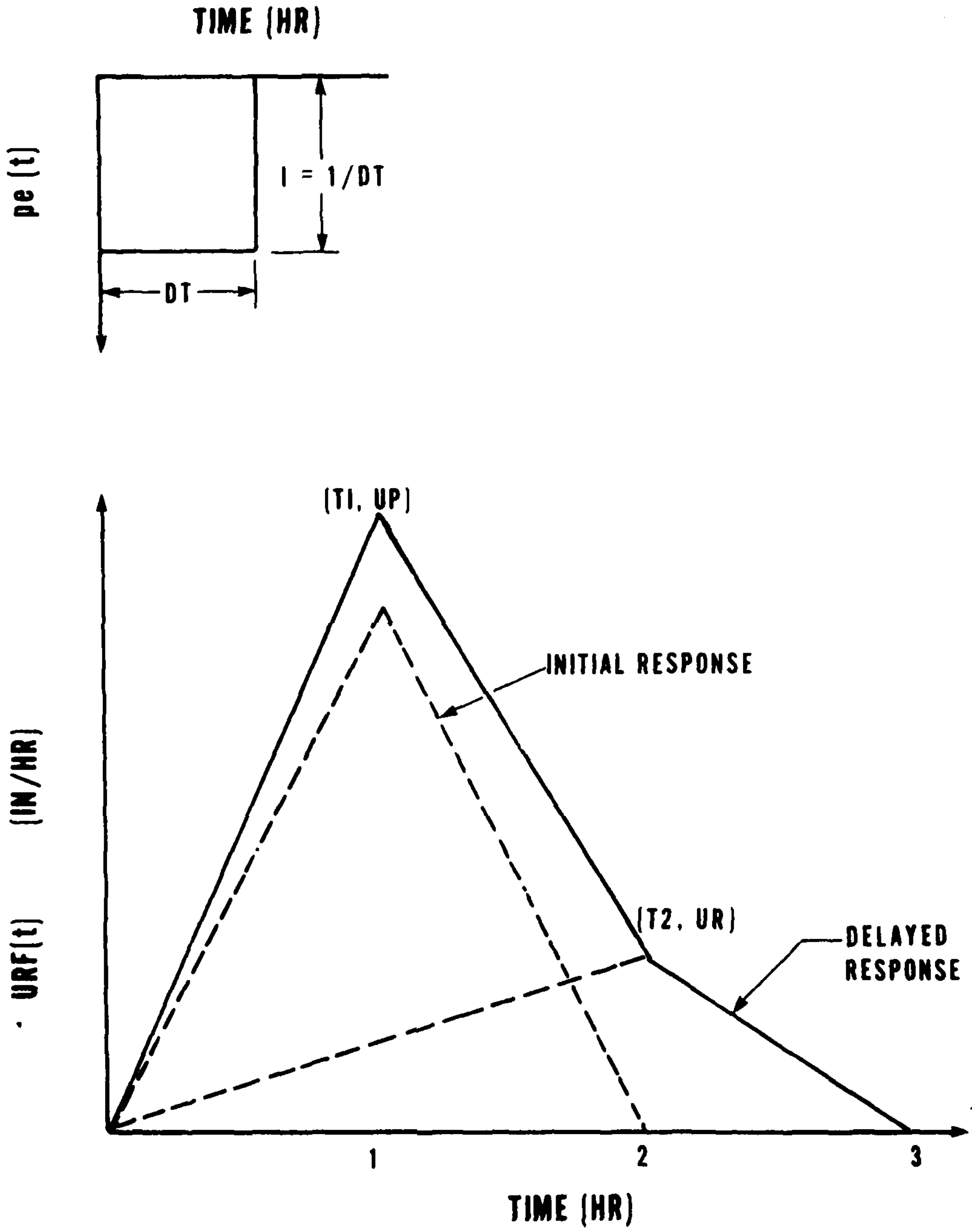


Figure 1. Double Triangle Model for Unit Response Function.

UP = Peak of unit response function at T1.

UR = Peak of delayed response at T2.

T1 = Time to peak of initial response, hours.

T2 = Time base of initial response and equal to the time of peak of delayed response, hours.

T3 = Time of end of delayed response, hours.

pe(t) = precipitation excess as a function of time, t, in inches per hour.

URF(t) = unit response function ordinate as a function of time, t, in inches per hour.

In deriving the URF, it is assumed that the peak of the delayed response (UR) occurs at the end of the initial response (T2), and the time bases of both responses and the time to peak of the initial response are integer multiples of DT. No assumption is made concerning the relative volumes contained in the initial and delayed responses or concerning the relative magnitudes of the peaks of the individual responses.

The double triangle URF is defined by the five parameters UP, UR, T1, T2, and T3. T3 is determined by:

$$T3 = (NOBS - NRAIN + 1) * DT$$

where NOBS = number of storm hydrograph ordinates in multiples of DT and NRAIN = number of rainfall increments in multiples of DT.

By maintaining a unit volume, UR is calculated from:

$$UR = (2 -[UP*T2]/[T3-T1])$$

Therefore, defining a storm URF involves determining values of UP, T1, and T2.

The parameters UP, T1, and T2 are optimized using the pattern search technique. The objective function is the minimization of the sum of squares of errors between observed and simulated discharges. Since all five parameters describing the model are allowed to vary from storm to storm, the model is considered nonlinear. Rainfall excess is optimized using the SCS-Curve Number model after setting it equal to the observed direct runoff volume.

The variability of the URF from storm to storm within a watershed was explained by normalizing the time and discharge scale by the associated URF lag time, TL, where TL = time lapse between occurrences of 50 percent of the rainfall excess block and 50 percent of the URF volume. These normalized URFs are referred to as NURFs.

The NURF for each major land use category has been identified empirically, and are shown in Figure 2. The categories are: strip mined, 100 percent forest, urban without extensive storm sewers, urban with extensive storm sewers, and agricultural. As a matter of providing a reference, the NURF

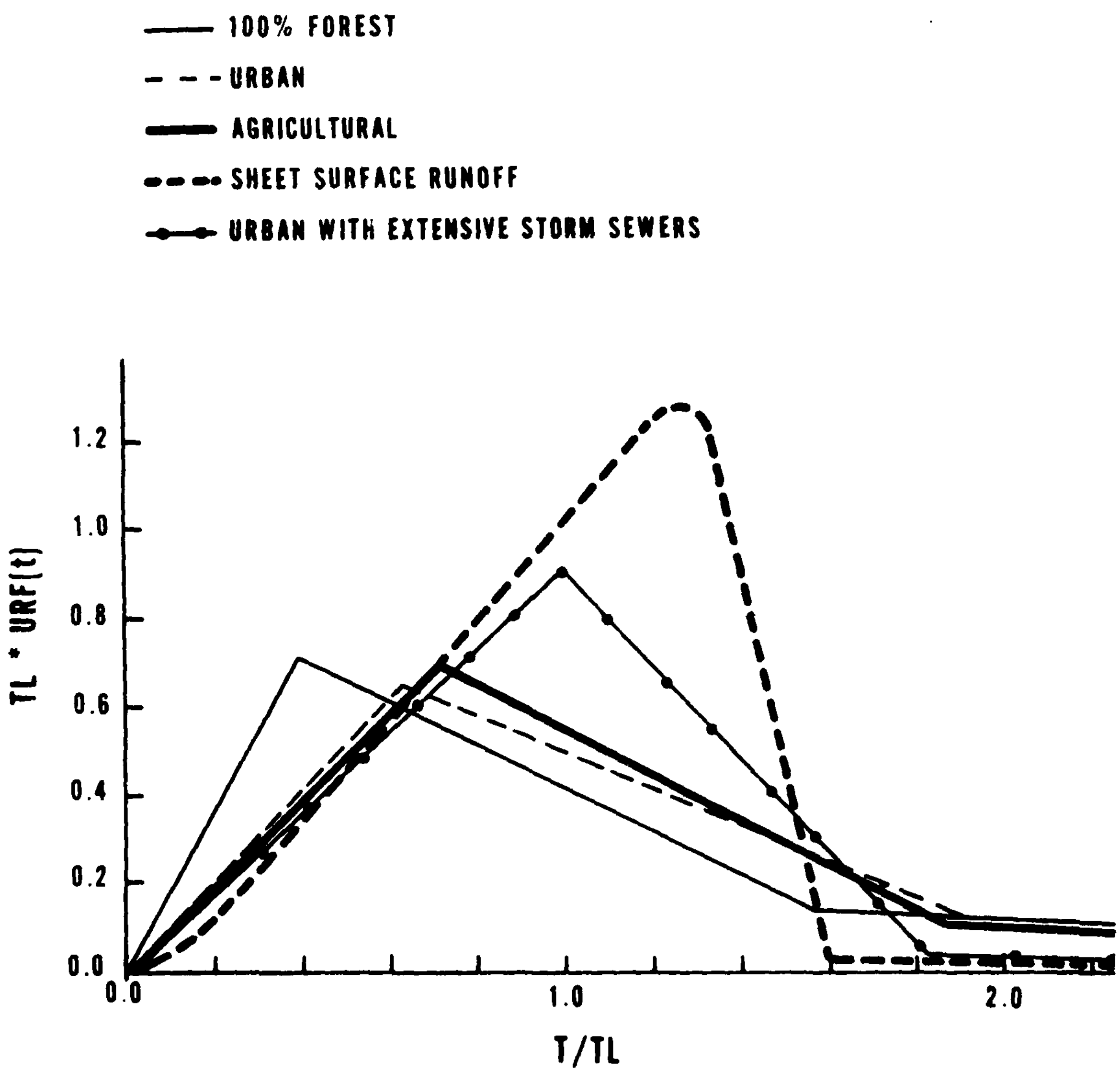


Figure 2. NURF for Various Land Use Conditions.

observed for sheet surface runoff from a plane (Reference 6) is shown. The strip mined watersheds were previously in 100 percent forested areas. Hence, a pattern is shown where the forested and strip mined watersheds have a small initial response whereas the urban and agricultural watersheds have a larger initial response. This implies that imperviousness and crop land produce much more surface runoff. The storm sewered NURF has an even higher initial response, which is generated by runoff collection systems. Sheet surface runoff has no delayed response.

b. Lag Time

Lag time, TL, for a storm is simulated in AFRUM using the concept that it varies inversely with the rainfall excess intensity. AFRUM uses a weighted rainfall excess intensity (WRE)

$$WRE = \sum_{j=1}^{N} i_e^{2}(j) / \sum_{j=1}^{N} i_e(j) \tag{8}$$

where N is the number of time intervals equal to DT. The weighted storm rainfall intensity is given the exponent 0.4 (References 4 and 5). The following equation is used to calculate the time lag

$$TL\ (min) = \mu / WRE^{0.4} \tag{9}$$

where lag modulus, μ, is empirically related to watershed characteristics in the following manner:

(1) For rural watersheds

$$\mu(hr) = 0.060 * SQMI + 0.0203 *PF + 1.16 \quad (10)$$

(2) For urban watersheds

$$\mu(hr) = 3.24 \, (SQMI/PI)^{0.6} \quad (11)$$

c. Convolution of URF

The final step in simulating a stormwater hydrograph is to convolute the storm URF with the rainfall excess time distribution. The URF is defined by simulating storm lag time from Equation (9) using with either Equation (10) or (11), depending on the watershed land use. WRE is calculated by Equation (8).

3. Simulation of Pollutant Yield

a. Load Modulus

AFRUM simulates storm pollutant yield using a load modulus (lb/acre-in of storm runoff) as a function of percent stripped or denuded (PS), lag modulus (μ), and percent forest or trees (PF), in the following form:

$$\mu_w = C_1 * PS - C_2 * \mu * PF + C_3 \quad (12)$$

The coefficients were optimized using stormwater quality data on a total of eleven watersheds; six of them were undergoing coal

strip mining and five were urbanized (Reference 5). Equation (12) was derived from a mass balance, and each of its terms represents a component of pollutant yield.

$C_1 * PS$ = source of pollutant or soil loss

$C_2 * \mu * PF$ = deposition between source and outfall, and

C_3 = storage in watershed picked up and redeposited.

The coefficients optimized for the coal strip mined and urbanized watersheds are shown in Table 2. The coefficients were previously presented in References 4 and 5.

b. Storm Load

Once load modulus for the watershed pollutant has been simulated, the storm pollutant yield, SPY, is simulated by

$$SPY = \mu_w * AREA * 640 * SRO \tag{13}$$

where SRO is the total storm runoff in surface inches, and AREA is in acres.

TABLE 2. COEFFICIENTS IN POLLUTANT YIELD MODEL

FOR EQUATION (12)

URBAN

Pollutant	Coefficients Source C_1	Deposition C_2	Storage C_3
Suspended Solids	16.7	21.5	62.3
Fe	0.442	0.568	1.54
Mn	0.0072	0.0092	0.20
Ca	0.147	0.189	2.45
Mg	0.0597	0.113	0.0323
Sulfate	0.0719	0.0216	1.24
Total Alkalinity	0.319	0.128	6.71
COAL STRIP MINED (Active)			
Suspended Solids	18.2	1.28	576.7
Fe	0.323	0	0.12
Mn	0.0161	0	0.002
Ca	0.131	0	0.38
Mg	0.133	0	0.40
Sulfate	1.39	0	2.45
Total Alkalinity	0.19	0	2.00

SECTION V

INSTRUCTIONS FOR DATA PREPARATION

The data cards should be prepared according to Figure 3 and Table 3. Figure 3 shows the layout of the data cards in the order in which they must be read into the computer. Table 3 shows how the data are to be punched and lists the description of variables used in the program.

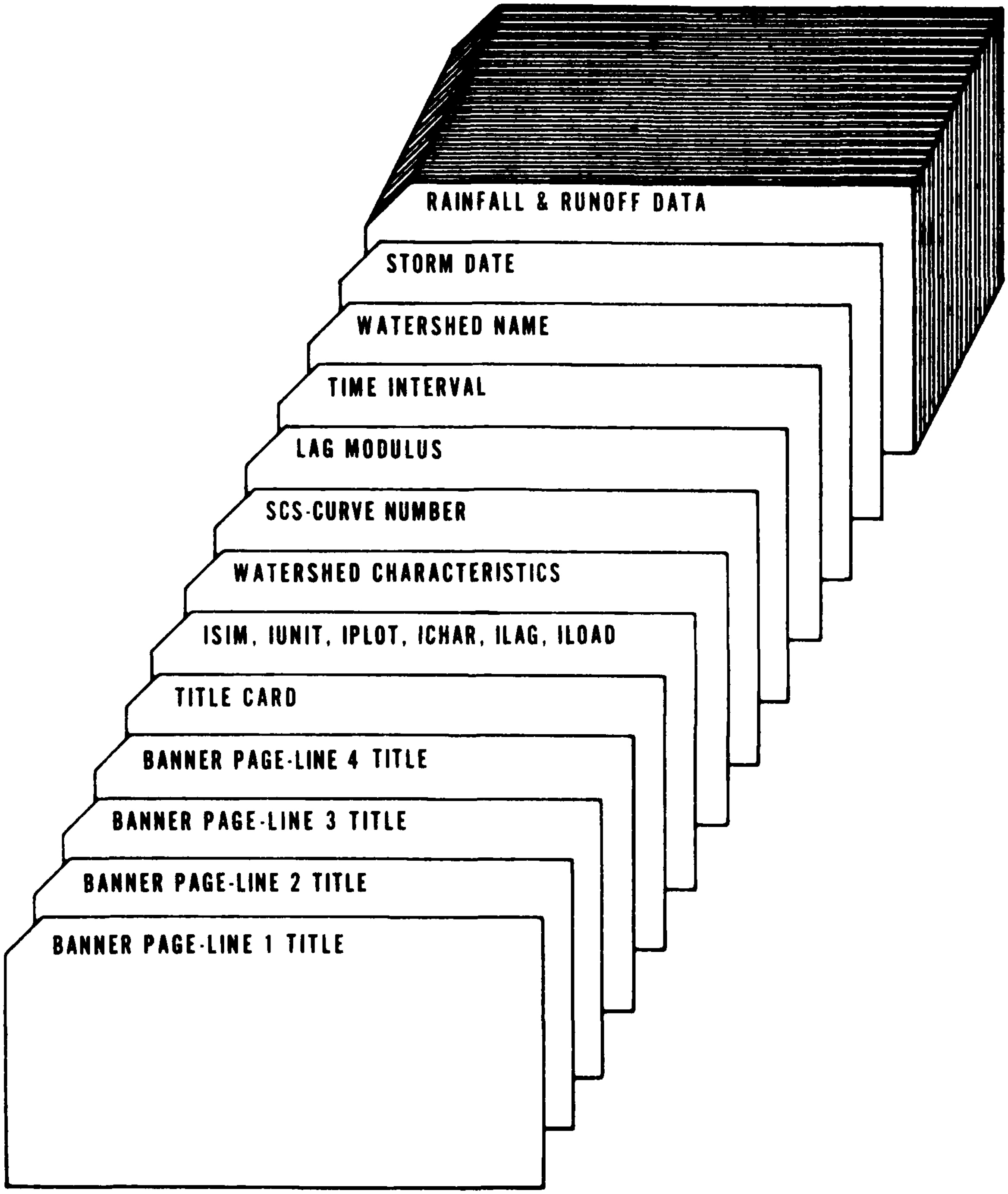


Figure 3. Data Deck for AFRUM

TABLE 3. AFRUM CARD DATA

U.S. AIR FORCE RUNOFF MODEL (AFRUM)

A STORM HYDROGRAPH SIMULATION MODEL DEVELOPED FOR THE AIR FORCE ENGINEERING SERVICES CENTER, TYNDALL AFB, FLORIDA BY DR DONALD OVERTON OF THE UNIVERSITY OF TENNESSEE, PRINCIPAL INVESTIGATOR AND GEORGE W. SCHLOSSNAGLE, CAPT USAF, BSC, PROJECT OFFICER

AFRUM

CARD NO.	FORMAT/ COLUMNS	VARIABLE NAMES AND DESCRIPTION
1	(12A1)/ (1-12)	BANNER PAGE - 1ST LINE -- USER DESCRIPTION
2	(12A1)/ (1-12)	BANNER PAGE - 2ND LINE -- USER DESCRIPTION
3	(12A1)/ (1-12)	BANNER PAGE - 3RD LINE -- USER DESCRIPTION
4	(12A1)/ (1-12)	BANNER PAGE - 4TH LINE -- USER DESCRIPTION
5	(20A4)/ (1-80)	TITLE NAME AND LOCATION OF WATERSHED
6	(6I4)/	ISIM,IUNIT,IPLOT,ICHAR,ILAG,ILOAD
	(1-4)	ISIM-A CONTROL VARIABLE TO SPECIFY THE TYPE OF DATA SUPPLIED TO THE PROGRAM ISIM=1 ONLY RAINFALL DATA IS SUPPLIED AND AN ESTIMATE MUST BE MADE OF THE SCS CURVE NUMBER
	(5-8)	IUNIT-A CONTROL PARAMETER TO SPECIFY OUTPUT UNITS OF SIMULATED HYDROGRAPH IUNIT=0 UNITS ARE IN INCHES/HR IUNIT=1 UNITS ARE IN CFS
	(9-12)	IPLOT-A CONTROL PARAMETER TO DETERMINE IF OUTPUT IS PLOTTED IPLOT=0 NO PLOT IS PRODUCED IPLOT=1 A PLOT IS PRODUCED
	(13-16)	ICHAR-A CONTROL PARAMETER TO SPECIFY IF LAND USE IS URBAN (WITH OR WITHOUT EXTENSIVE STORM SEWERS), AGRICULTURAL, COAL STRIP MINED OR 100% FOREST ICHAR=0 URBAN WITHOUT STORM SEWERS ICHAR=1 URBAN WITH STORM SEWERS ICHAR=2 COAL STRIP MINED ICHAR=3 AGRICULTURAL ICHAR=4 FORESTED

TABLE 3. AFRUM CARD DATA (CONTINUED)

```
    (17-20)        ILAG-A CONTROL PARAMETER TO DETERMINE IF LAG
                        MODULUS IS READ IN OR SIMULATED FROM
                        WATERSHED CHARACTERISTICS
                   ILAG=0  LAG MODULUS IS READ IN
                   ILAG=1  LAG MODULUS IS SIMULATED FROM URBAN
                           WATERSHED CHARACTERISTICS (% IMPERVIOUS
                           AND AREA [SQMI])
                   ILAG=2  LAG MODULUS IS SIMULATED FROM RURAL
                           WATERSHED CHARACTERISTICS (% FOREST AND
                           AREA [SQMI])
    (21-24)        ILOAD-A CONTROL PARAMETER TO DETERMINE HOW
                         SUSPENDED SEDIMENT STORM LOAD IS TO BE
                         SIMULATED FROM % FOREST, % IMPERVIOUS,
                         % STRIPPED AND LAG MODULUS
                   ILOAD=1  URBAN WATERSHED
                   ILOAD=2  COAL STRIP MINED WATERSHED

WATERSHED CHARACTERISTICS:  ID URBAN,PS=0; IF RURAL,PI=0
7      (4F8.0)/    SQMI,PF,PS,PI

       (1-8)       SQMI=WATERSHED AREA IN SQUARE MILES
       (9-16)      PF=PERCENT FOREST
       (17-24)     PS=PERCENT COAL STRIP MINED (OR DENUDED)

CARD A IS NOT REQUIRED IF ISIM=0 (CARD 5)

8      (F10.0)/    CN
       (1-10)      CN=SCS CURVE NUMBER FOR WATERSHED AT THE TIME
                      THE STORM OCCURED (VARIES WITH ANTECEDENT
                      MOISTURE)

CARD 9 IS NOT REQUIRED IF ILAG=1 or 2 (CARD 5)

9      (F10.0)/    U
       (1-10)      U=LAG MODULUS, HOURS

10     (F10.0)/    DT
       (1-10)1     DT=TIME INTERVAL USED IN ABSTRACTING RAINFALL
                   (HRS)

CARD 11,12, and 13 MUST BE REPEATED FOR EACH STORM TO BE
SIMULATED

11     (8A4)/      BASIN
       (1-32)      BASIN=NAME OF WATERSHED
```

TABLE 3. AFRUM CARD DATA (CONCLUDED)

12	(2A4)/	BDATE BDATE=DATE OF STORM
13	(I1,9X, F10.3,30X, F10.3)/	ISTAGE,RAIN(I),SFLOW(I)
	(1)	ISTAGE-A CONTROL PARAMETER TO SIGNAL THE END OF A STORM DATA SET ISTAGE=0 SIGNALS CONTINUATION OF RAINFALL/ RUNOFF ISTAGE=1 SIGNALS LAST DATA CARD OF A STORM
	(2-10)	BLANk
	(11-20)	RAIN(I) RAIN(I)=CUMULATIVE STORM RAINFALL ABSTRACTED AT DT TIME INTERVALS. THE FIRST VALUE OF RAIN(I) MUST BE 0.0 AT TIME 0.0
	(21-50)	BLANK
	(51-60)	SFLOW(I) SFLOW(I)=STORMWATER DISCHARGED IN CFS, ABSTRACTED AT DT TIME INTERVALS, VALUES OF SFLOW(I) ARE NOT REQUIRED IF ISIM=1 (CARD 1). THE FIRST AND LAST VALUES OF SFLOW(I) MUST BE 0.0

NO. OF RAINFALL/RUNOFF CARDS MUST BE EQUAL TO NUMBER OF RAINFALL/ RUNOFF OBSERVATIONS
A MAXIMUM OF 500 RAINFALL/RUNOFF OBSERVATIONS MAY BE SUBMITTED

SECTION VI

EXAMPLE PROBLEMS

1. McDowell Ditch

An example application of AFRUM is provided for the McDowell Ditch watershed at Grissom Air Force Base, Indiana. The watershed is 276 acres in size, has 20 percent imperviousness, and essentially zero percent trees. The soils are classified in SCS group C and watershed land use is considered to be urban without extensive storm sewers.

The accumulated rainfall and hydrograph for the storm of November 14, 1978 was measured for the McDowell watershed. Since the runoff was available, the storm CN was calculated within AFRUM. However, using the SCS-CN method (see Table 3) the CN for the storm was estimated to be 83, whereas the calculated CN using storm rainfall and runoff was 81. This produced an error of 3.1 percent.

Hence, the data was punched onto the cards into the specified format and entered into the computer after the appropriate JCLs. A listing of the input and the program output follows.

```
AFRUM
GRISSOM AFB
14 NOV 78
MCDOWELL DIT
          GRISSOM AFB
   0   1   1   0   1   1
    0.43     5.5      0.0     22.0
      0.25
   MCDOWELL DITCH
11-14-78
          0.0
          0.05
          0.10
          0.15
          0.20
          0.20
          0.20
          0.20
          0.20
          0.30
          0.31
          0.34
          0.35
          0.40
          0.43
          0.48
          0.55
          0.60
          0.70
          0.82
          0.92
          1.00
          1.08
          1.14
          1.21
          1.23                                      0.006
          1.24                                      0.2
          1.26                                      0.3
          1.27                                      0.6
          1.28                                      1.1
          1.29                                      1.7
          1.30                                      2.5
          1.30                                      3.5
          1.33                                      4.6
          1.36                                      5.8
          1.38                                      6.5
          1.38                                      7.6
          1.45                                      8.5
          1.46                                      9.7
          1.47                                      10.8
          1.47                                      11.6
          1.47                                      12.1
          1.48                                      12.6
          1.48                                      13.0
          1.49                                      12.4
                                                    11.6
                                                    10.7
                                                    9.9
                                                    8.9
                                                    7.9
                                                    7.7
                                                    7.5
                                                    7.7
                                                    7.9
                                                    7.7
                                                    7.5
                                                    7.3
                                                    7.1
                                                    7.0
                                                    6.7
                                                    6.6
                                                    6.4
                                                    6.2
                                                    5.0
```

4.7
4.4
4.2
4.1
3.8
3.5
3.2
2.9
2.9
2.9
2.9
2.9
2.9
2.4
2.1
1.9
1.8
1.8
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.8
0.8
0.8
0.8
0.75
0.71
0.65
0.61
0.61
0.6
0.6
0.55
0.47
0.47
0.47
0.47
0.47
0.47
0.47
0.47
0.47
0.43
0.4
0.37
0.33
0.32
0.3
0.29
0.28
0.28
0.27
0.26
0.24
0.24
0.24
0.24
0.24
0.23
0.23
0.22
0.22
0.10
0.05

AFRUM

GRISSOM AFB

14 NOV 78

MCDOWELL DIT

INTRODUCTION

THE U.S. AIR FORCE RUNOFF MODEL (AFRUM) FOR SIMULATING STORM HYDROGRAPHS AND POLLUTANT YIELDS WAS DEVELOPED FOR THE AIR FORCE BY THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF TENNESSEE, KNOXVILLE AND THE RESEARCH AND DEVELOPMENT DIRECTORATE OF THE AIR FORCE ENGINEERING SERVICES CENTER (AFESC), TYNDALL AIR FORCE BASE, FLORIDA. DR. DONALD E. OVERTON OF THE UNIVERSITY OF TENNESSEE WAS THE PRINCIPAL INVESTIGATOR AND DR. GEORGE W. SCHLOSSNAGLE OF THE U.S. AIR FORCE WAS THE PROJECT OFFICER. THE RESULTS OF THREE SEPARATE BUT COMPLIMENTARY STUDIES WERE INCORPORATED INTO AFRUM. EACH OF THE THREE STUDIES HAD THE FUNDAMENTAL OBJECTIVE TO EVALUATE THE EFFECTS OF SPECIALIZED LAND USE ON STORMWATER RUNOFF AND ITS ASSOCIATED QUALITY. THE THREE STUDIES WERE FUNDED BY THE U.S. DEPARTMENT OF ENERGY, THE U.S. DEPARTMENT OF INTERIOR AND THE U.S. AIR FORCE. THE STUDY PERIOD WAS FROM 1975 THROUGH 1979. AFRUM WAS DEVELOPED IN THE COURSE OF ANALYZING 410 STORM EVENTS ON 36 WATERSHEDS, WHICH INCLUDED AGRICULTURAL, URBAN AND FORESTED LAND USE CONDITIIONS AS WELL AS COAL STRIP MINING AND THREE WATERSHEDS ON A U.S. AIR FORCE BASE.

AFRUM WAS DEVELOPED FOR THE PURPOSE OF SIMULATING STORMWATER HYDROGRAPHS FROM ACTUAL OR DESIGN STORM RAINFALL DISTRIBUTIONS, LAND USE CHARACTERISTICS AND SOIL TYPE IN THE WATERSHED OF CONCERN. THE REQUIRED INPUT BASIN CHARACTERISTICS ARE:

1. PERCENT OF WATERSHED THAT IS FORESTED
2. PERCENT OF WATERSHED THAT IS IMPERVIOUS
3. PERCENT OF WATERSHED THAT IS DENUDED OR STRIP MINED
4. SURFACE DRAINAGE AREA

RUNOFF VOLUME AND THE ASSOCIATED RAINFALL EXCESS TIME DISTRIBUTION ARE SIMULATED FROM INPUT RAINFALL USING THE U.S. SOIL CONSERVATION SERVICE CURVE NUMBER. IF A RUNOFF HYDROGRAPH IS PROVIDED WITH THE ASSOCIATED RAINFALL HYETOGRAPH, AFRUM WILL COMPUTE THE CURVE NUMBER, CN; OTHERWISE CN MUST BE AN INPUT. CN IS SELECTED BY USING THE PROCEDURES PROVIDED IN THE NATIONAL ENGINEERING HANDBOOK, SECTION 4, U.S. SOIL CONSERVATION SERVICE.

AFRUM MAKES PROVISION FOR SIMULATING A UNIT HYDROGRAPH OR UNIT RESPONSE FUNCTION, WHICH IS CONVOLUTED WITH THE RAINFALL EXCESS HYETOGRAPH. AFRUM ALSO SIMULATES POLLUTANT LOADS FOR THE INPUTED STORM. THIS SIMULATION IS A FUNCTION OF THE SPECIFIED WATERSHED AND STORM CHARACTERISTICS.

GRISSOM AFB

THE WATERSHED NAME IS MCDOWELL DITCH

THE DATE OF THE RAINFALL EVENT IS 11-14-78

THE WATERSHED SIZE IN SQUARE MILES IS:	SQMI=	.43
THE PERCENT OF THE BASIN WHICH IS FOREST IS:	PF=	5.50
THE PERCENT OF THE BASIN DENUDED IS:	PS=	0.00
THE PERCENT OF THE BASIN WHICH IS IMPERVIOUS IS:	PI=	22.00

BY SETTING ISIM = 0 YOU HAVE INDICATED THAT YOU PLAN TO SUPPLY EITHER ACTUAL OR DESIGN RAINFALL AND RUNOFF DATA; THEREFORE, THE SCS CURVE NUMBER, CN, WILL BE DETERMINED BY SETTING RUNOFF EQUAL TO PRECIPITATION EXCESS.

OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS AND CUBIC FEET PER SECOND, CFS, AS SELECTED BY SETTING IUNIT = 1.

YOU HAVE REQUESTED THAT THE HYDROGRAPH BE PLOTTED BY SETTING IPLOT = 1.

THE WATERSHED IS ASSUMED TO BE URBAN WITHOUT STORM SEWERS; ICHAR = 0.

YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN HOURS ASSUMING IT IS A FUNCTION OF THE WATERSHED AREA AND PERCENT IMPERVIOUS AREA OF THE WATERSHED; ILAG = 1.

SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE WATERSHED IS RURAL OR URBAN WITHOUT MAJOR CONSTRUCTION; ILOAD = 1.

TABLE I. USER INPUT

TIME (HR)	TOTAL RAIN (IN)	INCREMENTAL RAIN (IN)	OBSERVED DATA FLOW (CFS)	OBSERVED DATA FLOW (IN/HR)
0.00	0.00	0.00	0.00	0.00000
.25	.05	.05	0.00	0.00000
.50	.10	.05	0.00	0.00000
.75	.15	.05	0.00	0.00000
1.00	.20	.05	0.00	0.00000
1.25	.20	0.00	0.00	0.00000
1.50	.20	0.00	0.00	0.00000
1.75	.20	0.00	0.00	0.00000
2.00	.20	0.00	0.00	0.00000
2.25	.30	.10	0.00	0.00000
2.50	.31	.01	0.00	0.00000
2.75	.34	.03	0.00	0.00000
3.00	.35	.01	0.00	0.00000
3.25	.40	.05	0.00	0.00000
3.50	.43	.03	0.00	0.00000
3.75	.48	.05	0.00	0.00000
4.00	.55	.07	0.00	0.00000
4.25	.60	.05	0.00	0.00000
4.50	.70	.10	0.00	0.00000
4.75	.82	.12	0.00	0.00000
5.00	.92	.10	0.00	0.00000
5.25	1.00	.08	0.00	0.00000
5.50	1.08	.08	0.00	0.00000
5.75	1.14	.06	0.00	0.00000
6.00	1.21	.07	0.00	0.00000
6.25	1.23	.02	.01	.00002
6.50	1.24	.01	.20	.00072
6.75	1.26	.02	.30	.00108
7.00	1.27	.01	.60	.00216
7.25	1.28	.01	1.10	.00396
7.50	1.29	.01	1.70	.00613
7.75	1.30	.01	2.50	.00901
8.00	1.30	0.00	3.50	.01261
8.25	1.33	.03	4.60	.01658
8.50	1.36	.03	5.80	.02090
8.75	1.38	.02	6.50	.02342
9.00	1.38	0.00	7.60	.02739
9.25	1.45	.07	8.50	.03063
9.50	1.46	.01	9.70	.03496
9.75	1.47	.01	10.80	.03892
10.00	1.47	0.00	11.60	.04180
10.25	1.47	0.00	12.10	.04360
10.50	1.48	.01	12.60	.04541
10.75	1.48	0.00	13.00	.04685
11.00	1.49	.01	12.40	.04469
11.25	0.00	0.00	11.60	.04180
11.50	0.00	0.00	10.70	.03856
11.75	0.00	0.00	9.90	.03568
12.00	0.00	0.00	8.90	.03207
12.25	0.00	0.00	7.90	.02847
12.50	0.00	0.00	7.70	.02775
12.75	0.00	0.00	7.50	.02703
13.00	0.00	0.00	7.70	.02775
13.25	0.00	0.00	7.90	.02847
13.50	0.00	0.00	7.70	.02775
13.75	0.00	0.00	7.50	.02703
14.00	0.00	0.00	7.30	.02631
14.25	0.00	0.00	7.10	.02559
14.50	0.00	0.00	7.00	.02523
14.75	0.00	0.00	6.70	.02414
15.00	0.00	0.00	6.60	.02378
15.25	0.00	0.00	6.40	.02306
15.50	0.00	0.00	6.20	.02234
15.75	0.00	0.00	5.00	.01802

TABLE I. USER INPUT (CONTINUED)

16.00	0.00	0.00	4.70	.01694
16.25	0.00	0.00	4.40	.01586
16.50	0.00	0.00	4.20	.01514
16.75	0.00	0.00	4.10	.01478
17.00	0.00	0.00	3.80	.01369
17.25	0.00	0.00	3.50	.01261
17.50	0.00	0.00	3.20	.01153
17.75	0.00	0.00	2.90	.01045
18.00	0.00	0.00	2.90	.01045
18.25	0.00	0.00	2.90	.01045
18.50	0.00	0.00	2.90	.01045
18.75	0.00	0.00	2.90	.01045
19.00	0.00	0.00	2.90	.01045
19.25	0.00	0.00	2.40	.00865
19.50	0.00	0.00	2.10	.00757
19.75	0.00	0.00	1.90	.00685
20.00	0.00	0.00	1.80	.00649
20.25	0.00	0.00	1.80	.00649
20.50	0.00	0.00	1.60	.00577
20.75	0.00	0.00	1.50	.00541
21.00	0.00	0.00	1.40	.00505
21.25	0.00	0.00	1.30	.00468
21.50	0.00	0.00	1.20	.00432
21.75	0.00	0.00	1.10	.00396
22.00	0.00	0.00	1.00	.00360
22.25	0.00	0.00	.90	.00324
22.50	0.00	0.00	.80	.00288
22.75	0.00	0.00	.80	.00288
23.00	0.00	0.00	.80	.00288
23.25	0.00	0.00	.80	.00288
23.50	0.00	0.00	.80	.00288
23.75	0.00	0.00	.75	.00270
24.00	0.00	0.00	.71	.00256
24.25	0.00	0.00	.65	.00234
24.50	0.00	0.00	.61	.00220
24.75	0.00	0.00	.61	.00220
25.00	0.00	0.00	.60	.00216
25.25	0.00	0.00	.60	.00216
25.50	0.00	0.00	.55	.00198
25.75	0.00	0.00	.47	.00169
26.00	0.00	0.00	.47	.00169
26.25	0.00	0.00	.47	.00169
26.50	0.00	0.00	.47	.00169
26.75	0.00	0.00	.47	.00169
27.00	0.00	0.00	.47	.00169
27.25	0.00	0.00	.47	.00169
27.50	0.00	0.00	.47	.00169
27.75	0.00	0.00	.47	.00169
28.00	0.00	0.00	.43	.00155
28.25	0.00	0.00	.40	.00144
28.50	0.00	0.00	.37	.00133
28.75	0.00	0.00	.33	.00119
29.00	0.00	0.00	.32	.00115
29.25	0.00	0.00	.30	.00108
29.50	0.00	0.00	.29	.00105
29.75	0.00	0.00	.28	.00101
30.00	0.00	0.00	.28	.00101
30.25	0.00	0.00	.27	.00097
30.50	0.00	0.00	.26	.00094
30.75	0.00	0.00	.24	.00086
31.00	0.00	0.00	.24	.00086
31.25	0.00	0.00	.24	.00086
31.50	0.00	0.00	.24	.00086
31.75	0.00	0.00	.24	.00086
32.00	0.00	0.00	.23	.00083
32.25	0.00	0.00	.23	.00083
32.50	0.00	0.00	.22	.00079

TABLE I. USER INPUT (CONCLUDED)

32.75	0.00	0.00	.22	.00079
33.00	0.00	0.00	.10	.00036
33.25	0.00	0.00	.05	.00018
33.50	0.00	0.00	0.00	0.00000

RFI	U	N	TL	UP	UR	T1	T2	T3	AREA
.085	.306	.400	.820	.809	.146	.500	1.500	5.750	.991

ADJUSTED HYDROGRAPH PARAMETERS

UP	UR	T1	T2	T3	AREA
.816	.148	.500	1.500	5.750	1.000

TABLE II. HYDROGRAPH OUTPUT

OBSERVED FLOW OUT OF WATERSHED (CFS)	PREDICTED FLOW OUT OF WATERSHED (CFS)	TIME (HOURS)	SUSPENDED SOLIDS DISCHARGED FROM WATERSHED LBS/SEC
0.000	0.000	0.000	0.000
0.000	0.000	.250	0.000
0.000	0.000	.500	0.000
0.000	0.000	.750	0.000
0.000	0.000	1.000	0.000
0.000	0.000	1.250	0.000
0.000	0.000	1.500	0.000
0.000	0.000	1.750	0.000
0.000	0.000	2.000	0.000
0.000	0.000	2.250	0.000
0.000	0.000	2.500	0.000
0.000	0.000	2.750	0.000
0.000	0.000	3.000	0.000
0.000	0.000	3.250	0.000
0.000	0.000	3.500	0.000
0.000	0.000	3.750	0.000
0.000	.024	4.000	.000
0.000	.426	4.250	.003
0.000	1.332	4.500	.010
0.000	3.384	4.750	.024
0.000	7.657	5.000	.055
0.000	12.749	5.250	.092
0.000	16.618	5.500	.120
0.000	19.440	5.750	.140
0.000	20.970	6.000	.151
.006	21.832	6.250	.157
.200	21.066	6.500	.152
.300	17.345	6.750	.125
.600	14.395	7.000	.104
1.100	12.532	7.250	.090
1.700	10.795	7.500	.078
2.500	10.149	7.750	.073
3.500	9.684	8.000	.070
4.600	8.678	8.250	.063
5.800	8.924	8.500	.064
6.500	11.002	8.750	.079
7.600	12.134	9.000	.087
8.500	11.168	9.250	.080
9.700	12.830	9.500	.092
10.800	15.075	9.750	.109
11.600	12.920	10.000	.093
12.100	10.588	10.250	.076
12.600	7.895	10.500	.057
13.000	5.856	10.750	.042
12.400	5.430	11.000	.039
11.600	5.056	11.250	.036
10.700	4.980	11.500	.036
9.900	4.125	11.750	.030
8.900	3.342	12.000	.024
7.900	2.808	12.250	.020
7.700	2.284	12.500	.016
7.500	2.013	12.750	.015
7.700	1.752	13.000	.013
7.900	1.503	13.250	.011
7.700	1.264	13.500	.009
7.500	1.037	13.750	.007
7.300	.810	14.000	.006
7.100	.617	14.250	.004
7.000	.458	14.500	.003

TABLE II. HYDROGRAPH OUTPUT (CONTINUED)

6.700	.323	14.750	.002
6.600	.188	15.000	.001
6.400	.138	15.250	.001
6.200	.101	15.500	.001
5.000	.076	15.750	.001
4.700	.050	16.000	.000
4.400	.025	16.250	.000
4.200	.013	16.500	.000
4.100	0.000	16.750	0.000
3.800	0.000	17.000	0.000
3.500	0.000	17.250	0.000
3.200	0.000	17.500	0.000
2.900	0.000	17.750	0.000
2.900	0.000	18.000	0.000
2.900	0.000	18.250	0.000
2.900	0.000	18.500	0.000
2.900	0.000	18.750	0.000
2.900	0.000	19.000	0.000
2.400	0.000	19.250	0.000
2.100	0.000	19.500	0.000
1.900	0.000	19.750	0.000
1.800	0.000	20.000	0.000
1.800	0.000	20.250	0.000
1.600	0.000	20.500	0.000
1.500	0.000	20.750	0.000
1.400	0.000	21.000	0.000
1.300	0.000	21.250	0.000
1.200	0.000	21.500	0.000
1.100	0.000	21.750	0.000
1.000	0.000	22.000	0.000
.900	0.000	22.250	0.000
.800	0.000	22.500	0.000
.800	0.000	22.750	0.000
.800	0.000	23.000	0.000
.800	0.000	23.250	0.000
.800	0.000	23.500	0.000
.750	0.000	23.750	0.000
.710	0.000	24.000	0.000
.650	0.000	24.250	0.000
.610	0.000	24.500	0.000
.610	0.000	24.750	0.000
.600	0.000	25.000	0.000
.600	0.000	25.250	0.000
.550	0.000	25.500	0.000
.470	0.000	25.750	0.000
.470	0.000	26.000	0.000
.470	0.000	26.250	0.000
.470	0.000	26.500	0.000
.470	0.000	26.750	0.000
.470	0.000	27.000	0.000
.470	0.000	27.250	0.000
.470	0.000	27.500	0.000
.470	0.000	27.750	0.000
.430	0.000	28.000	0.000
.400	0.000	28.250	0.000
.370	0.000	28.500	0.000
.330	0.000	28.750	0.000
.320	0.000	29.000	0.000
.300	0.000	29.250	0.000
.290	0.000	29.500	0.000
.280	0.000	29.750	0.000
.280	0.000	30.000	0.000
.270	0.000	30.250	0.000
.260	0.000	30.500	0.000
.240	0.000	30.750	0.000
.240	0.000	31.000	0.000
.240	0.000	31.250	0.000

TABLE II. HYDROGRAPH OUTPUT (CONCLUDED)

.240	0.000	31.500	0.000
.240	0.000	31.750	0.000
.230	0.000	32.000	0.000
.230	0.000	32.250	0.000
.220	0.000	32.500	0.000
.220	0.000	32.750	0.000
.100	0.000	33.000	0.000
.050	0.000	33.250	0.000
0.000	0.000	33.500	0.000

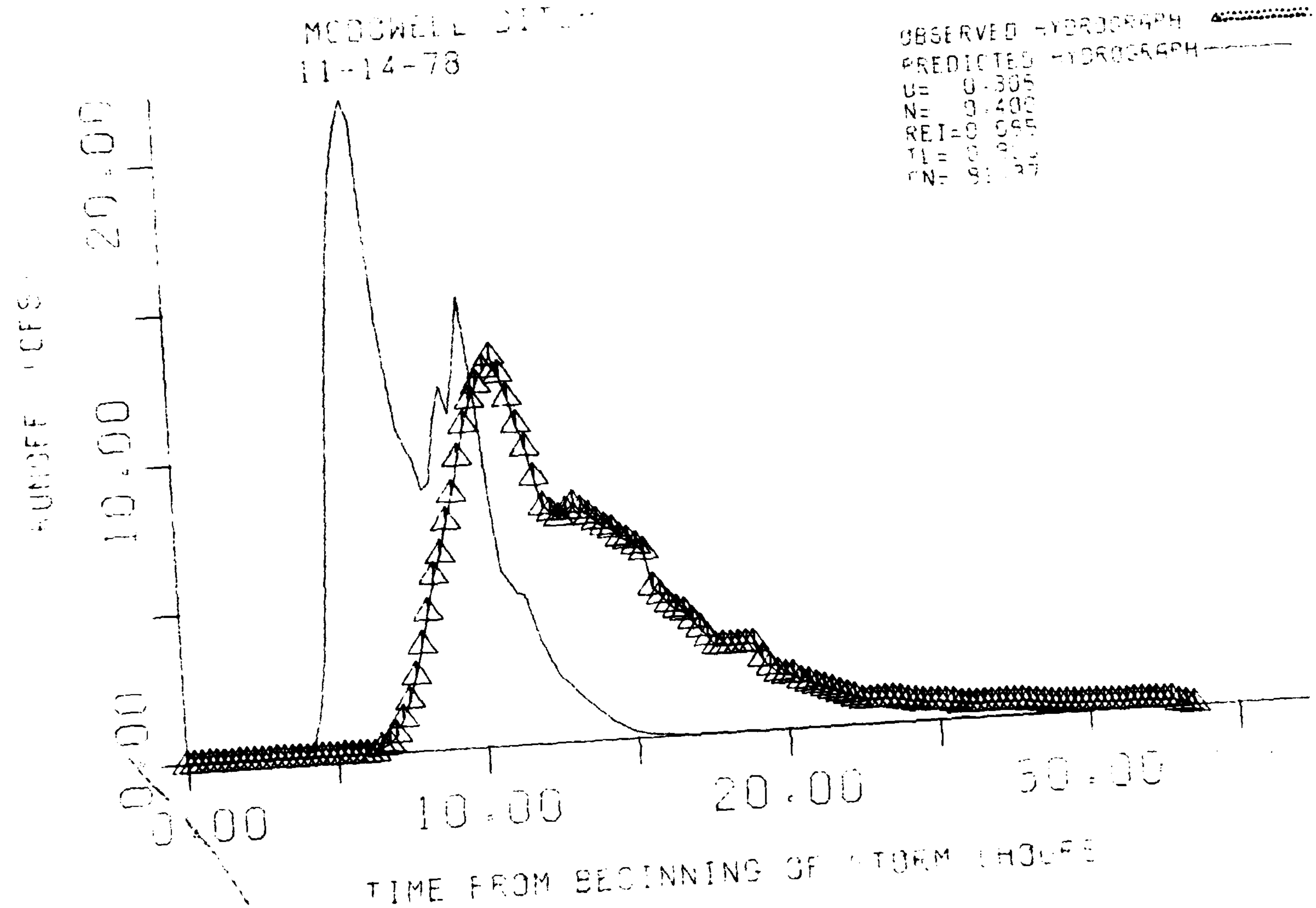
TOTAL SUSPENDED SOLIDS (LBS) DISCHARGED FROM WATERSHED
DURING STORM EVENT = 2308.209

FE CONC (PPM)	6.80680
FE LOAD (LBS)	135.87454
MN CONC (PPM)	.88400
MN LOAD (LBS)	17.64604
CA CONC (PPM)	10.82900
CA LOAD (LBS)	216.16404
MG CONC (PPM)	.14277
MG LOAD (LBS)	2.84984
SO4 CONC (PPM)	5.48080
SO4 LOAD (LBS)	109.40547
ALK CONC (PPM)	29.65820
ALK LOAD (LBS)	592.02478

KUP	KT1	KT2	KUR
.663	.632	1.880	.120

U	N	DT
.306	.400	.25000

SIMULATED LOAD MODULUS(LBS/AC-IN OF RUNOFF)
26.16



11-14-78
OBSERVED HYDROGRAPH
PREDICTED HYDROGRAPH
U= 0.305
N= 0.400
0.00
10.00
20.00
30.00
TIME FROM BEGINNING OF

2. Capehart Marina

An example is provided for the Capehart Marina watershed at Tyndall AFB, Florida. No runoff data is available, and a design storm is supplied. The design storm of interest is 10 inches of rainfall in 12 hours read in at increments of one tenth of an hour. The watershed area is 0.17 square mile with 14.5 percent forest, 1 percent denuded area, and 15 percent impervious area. Curve number 58 was selected from Table 1. The watershed is urban with storm sewers.

A listing of the input and output follows.

```
CAPEHART
MARINA, TAFB
AFTER
CONSTRUCTION
CAPEHART MARINA AFTER CONSTRUCTION )
    1    1    1    1    1    1
.17       14.5       1.       15.
  58.
 .1
CAPEHART MARINA -(AFTER)
04-22-80
               00.
               00.05
               00.1
               00.15
                 .2
                 .25
                 .3
                 .35
                 .40
                 .5
                 .55
                 .6
                 .65
                 .7
                 .75
                 .80
                 .85
                 .9
                 .95
                1.
                1.1
                1.2
                1.3
                1.4
                1.5
                1.6
                1.7
                1.8
                1.9
                2.0
                2.1
                2.2
                2.3
                2.4
                2.5
                2.6
                2.7
                2.8
                2.9
                3.0
                3.1
                3.2
                3.3
                3.4
                3.5
                3.6
                3.7
                3.8
                3.9
                4.0
                4.1
                4.2
                4.3
                4.4
                4.5
                4.6
                4.7
                4.8
                4.9
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             5.0
             5.1
             5.2
             5.3
             5.4
             5.5
             5.6
             5.7
             5.8
             5.9
             6.0
             6.15
             6.30
             6.45
             6.60
             6.75
             6.9
             7.0
             7.1
             7.2
             7.3
             7.4
             7.5
             7.6
             7.7
             7.8
             7.9
             8.0
             8.1
             8.2
             8.3
             8.4
             8.5
             8.6
             8.7
             8.8
             8.9
             9.0
             9.05
             9.10
             9.15
             9.20
             9.25
             9.30
             9.35
             9.40
             9.45
             9.50
             9.55
             9.60
             9.65
             9.70
             9.75
             9.80
             9.85
             9.90
             9.95
 1           10.
```

CAPEHART

MARINA TAFB

AFTER

CONSTRUCTION

INTRODUCTION

THE U.S. AIR FORCE RUNOFF MODEL (AFRUM) FOR SIMULATING STORM HYDROGRAPHS AND POLLUTANT YIELDS WAS DEVELOPED FOR THE AIR FORCE BY THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF TENNESSEE, KNOXVILLE AND THE RESEARCH AND DEVELOPMENT DIRECTORATE OF THE AIR FORCE ENGINEERING SERVICES CENTER (AFESC), TYNDALL AIR FORCE BASE, FLORIDA. DR. DONALD E. OVERTON OF THE UNIVERSITY OF TENNESSEE WAS THE PRINCIPAL INVESTIGATOR AND DR. GEORGE W. SCHLOSSNAGLE OF THE U.S. AIR FORCE WAS THE PROJECT OFFICER. THE RESULTS OF THREE SEPARATE BUT COMPLIMENTARY STUDIES WERE INCORPORATED INTO AFRUM. EACH OF THE THREE STUDIES HAD THE FUNDAMENTAL OBJECTIVE TO EVALUATE THE EFFECTS OF SPECIALIZED LAND USE ON STORMWATER RUNOFF AND ITS ASSOCIATED QUALITY. THE THREE STUDIES WERE FUNDED BY THE U.S. DEPARTMENT OF ENERGY, THE U.S. DEPARTMENT OF INTERIOR AND THE U.S. AIR FORCE. THE STUDY PERIOD WAS FROM 1975 THROUGH 1979. AFRUM WAS DEVELOPED IN THE COURSE OF ANALYZING 410 STORM EVENTS ON 36 WATERSHEDS, WHICH INCLUDED AGRICULTURAL, URBAN AND FORESTED LAND USE CONDITIIONS AS WELL AS COAL STRIP MINING AND THREE WATERSHEDS ON A U.S. AIR FORCE BASE.

AFRUM WAS DEVELOPED FOR THE PURPOSE OF SIMULATING STORMWATER HYDROGRAPHS FROM ACTUAL OR DESIGN STORM RAINFALL DISTRIBUTIONS, LAND USE CHARACTERISTICS AND SOIL TYPE IN THE WATERSHED OF CONCERN. THE REQUIRED INPUT BASIN CHARACTERISTICS ARE:

1. PERCENT OF WATERSHED THAT IS FORESTED
2. PERCENT OF WATERSHED THAT IS IMPERVIOUS
3. PERCENT OF WATERSHED THAT IS DENUDED OR STRIP MINED
4. SURFACE DRAINAGE AREA

RUNOFF VOLUME AND THE ASSOCIATED RAINFALL EXCESS TIME DISTRIBUTION ARE SIMULATED FROM INPUT RAINFALL USING THE U.S. SOIL CONSERVATION SERVICE CURVE NUMBER. IF A RUNOFF HYDROGRAPH IS PROVIDED WITH THE ASSOCIATED RAINFALL HYETOGRAPH, AFRUM WILL COMPUTE THE CURVE NUMBER, CN; OTHERWISE CN MUST BE AN INPUT. CN IS SELECTED BY USING THE PROCEDURES PROVIDED IN THE NATIONAL ENGINEERING HANDBOOK, SECTION 4, U.S. SOIL CONSERVATION SERVICE.

AFRUM MAKES PROVISION FOR SIMULATING A UNIT HYDROGRAPH OR UNIT RESPONSE FUNCTION, WHICH IS CONVOLUTED WITH THE RAINFALL EXCESS HYETOGRAPH. AFRUM ALSO SIMULATES POLLUTANT LOADS FOR THE INPUTED STORM. THIS SIMULATION IS A FUNCTION OF THE SPECIFIED WATERSHED AND STORM CHARACTERISTICS.

CAPEHART MARINA AFTER CONSTRUCTION

THE WATERSHED NAME IS CAPEHART MARINA -(AFTER)
THE DATE OF THE RAINFALL EVENT IS 04-22-80
THE WATERSHED SIZE IN SQUARE MILES IS: SQMI= .17
THE PERCENT OF THE BASIN WHICH IS FOREST IS: PF= 14.50
THE PERCENT OF THE BASIN DENUDED IS: PS= 1.00
THE PERCENT OF THE BASIN WHICH IS IMPERVIOUS IS: PI= 15.00

BY SETTING ISIM = 1 YOU HAVE INDICATED THAT YOU PLAN TO SUPPLY ACTUAL OR DESIGN RAINFALL DATA; THEREFORE, AN ESTIMATE OF THE SCS CURVE NUMBER, CN, MUST BE PROVIDED.

OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS AND CUBIC FEET PER SECOND, CFS, AS SELECTED BY SETTING IUNIT = 1.

YOU HAVE REQUESTED THAT THE HYDROGRAPH BE PLOTTED BY SETTING IPLOT = 1.

THE WATERSHED IS ASSUMED TO BE URBAN WITH STORM SEWERS; ICHAR = 1.

YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN HOURS ASSUMING IT IS A FUNCTION OF THE WATERSHED AREA AND PERCENT IMPERVIOUS AREA OF THE WATERSHED; ILAG = 1.

SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE WATERSHED IS RURAL OR URBAN WITHOUT MAJOR CONSTRUCTION; ILOAD = 1.

TABLE I. USER INPUT

TIME (HR)	TOTAL RAIN (IN)	INCREMENTAL RAIN (IN)	OBSERVED DATA FLOW (CFS)	OBSERVED DATA FLOW (IN/HR)
0.00	0.00	0.00	0.00	0.00000
.10	.05	.05	0.00	0.00000
.20	.10	.05	0.00	0.00000
.30	.15	.05	0.00	0.00000
.40	.20	.05	0.00	0.00000
.50	.25	.05	0.00	0.00000
.60	.30	.05	0.00	0.00000
.70	.35	.05	0.00	0.00000
.80	.40	.05	0.00	0.00000
.90	.50	.10	0.00	0.00000
1.00	.55	.05	0.00	0.00000
1.10	.60	.05	0.00	0.00000
1.20	.65	.05	0.00	0.00000
1.30	.70	.05	0.00	0.00000
1.40	.75	.05	0.00	0.00000
1.50	.80	.05	0.00	0.00000
1.60	.85	.05	0.00	0.00000
1.70	.90	.05	0.00	0.00000
1.80	.95	.05	0.00	0.00000
1.90	1.00	.05	0.00	0.00000
2.00	1.10	.10	0.00	0.00000
2.10	1.20	.10	0.00	0.00000
2.20	1.30	.10	0.00	0.00000
2.30	1.40	.10	0.00	0.00000
2.40	1.50	.10	0.00	0.00000
2.50	1.60	.10	0.00	0.00000
2.60	1.70	.10	0.00	0.00000
2.70	1.80	.10	0.00	0.00000
2.80	1.90	.10	0.00	0.00000
2.90	2.00	.10	0.00	0.00000
3.00	2.10	.10	0.00	0.00000
3.10	2.20	.10	0.00	0.00000
3.20	2.30	.10	0.00	0.00000
3.30	2.40	.10	0.00	0.00000
3.40	2.50	.10	0.00	0.00000
3.50	2.60	.10	0.00	0.00000
3.60	2.70	.10	0.00	0.00000
3.70	2.80	.10	0.00	0.00000
3.80	2.90	.10	0.00	0.00000
3.90	3.00	.10	0.00	0.00000
4.00	3.10	.10	0.00	0.00000
4.10	3.20	.10	0.00	0.00000
4.20	3.30	.10	0.00	0.00000
4.30	3.40	.10	0.00	0.00000
4.40	3.50	.10	0.00	0.00000
4.50	3.60	.10	0.00	0.00000
4.60	3.70	.10	0.00	0.00000
4.70	3.80	.10	0.00	0.00000
4.80	3.90	.10	0.00	0.00000
4.90	4.00	.10	0.00	0.00000
5.00	4.10	.10	0.00	0.00000
5.10	4.20	.10	0.00	0.00000
5.20	4.30	.10	0.00	0.00000
5.30	4.40	.10	0.00	0.00000
5.40	4.50	.10	0.00	0.00000
5.50	4.60	.10	0.00	0.00000
5.60	4.70	.10	0.00	0.00000
5.70	4.80	.10	0.00	0.00000
5.80	4.90	.10	0.00	0.00000
5.90	5.00	.10	0.00	0.00000

6.00	5.10	.10	0.00	0.00000
6.10	5.20	.10	0.00	0.00000
6.20	5.30	.10	0.00	0.00000
6.30	5.40	.10	0.00	0.00000
6.40	5.50	.10	0.00	0.00000
6.50	5.60	.10	0.00	0.00000
6.60	5.70	.10	0.00	0.00000
6.70	5.80	.10	0.00	0.00000
6.80	5.90	.10	0.00	0.00000
6.90	6.00	.10	0.00	0.00000
7.00	6.15	.15	0.00	0.00000
7.10	6.30	.15	0.00	0.00000
7.20	6.45	.15	0.00	0.00000
7.30	6.60	.15	0.00	0.00000
7.40	6.75	.15	0.00	0.00000
7.50	6.90	.15	0.00	0.00000
7.60	7.00	.10	0.00	0.00000
7.70	7.10	.10	0.00	0.00000
7.80	7.20	.10	0.00	0.00000
7.90	7.30	.10	0.00	0.00000
8.00	7.40	.10	0.00	0.00000
8.10	7.50	.10	0.00	0.00000
8.20	7.60	.10	0.00	0.00000
8.30	7.70	.10	0.00	0.00000
8.40	7.80	.10	0.00	0.00000
8.50	7.90	.10	0.00	0.00000
8.60	8.00	.10	0.00	0.00000
8.70	8.10	.10	0.00	0.00000
8.80	8.20	.10	0.00	0.00000
8.90	8.30	.10	0.00	0.00000
9.00	8.40	.10	0.00	0.00000
9.10	8.50	.10	0.00	0.00000
9.20	8.60	.10	0.00	0.00000
9.30	8.70	.10	0.00	0.00000
9.40	8.80	.10	0.00	0.00000
9.50	8.90	.10	0.00	0.00000
9.60	9.00	.10	0.00	0.00000
9.70	9.05	.05	0.00	0.00000
9.80	9.10	.05	0.00	0.00000
9.90	9.15	.05	0.00	0.00000
10.00	9.20	.05	0.00	0.00000
10.10	9.25	.05	0.00	0.00000
10.20	9.30	.05	0.00	0.00000
10.30	9.35	.05	0.00	0.00000
10.40	9.40	.05	0.00	0.00000
10.50	9.45	.05	0.00	0.00000
10.60	9.50	.05	0.00	0.00000
10.70	9.55	.05	0.00	0.00000
10.80	9.60	.05	0.00	0.00000
10.90	9.65	.05	0.00	0.00000
11.00	9.70	.05	0.00	0.00000
11.10	9.75	.05	0.00	0.00000
11.20	9.80	.05	0.00	0.00000
11.30	9.85	.05	0.00	0.00000
11.40	9.90	.05	0.00	0.00000
11.50	9.95	.05	0.00	0.00000
11.60	10.00	.05	0.00	0.00000

ESTIMATED CN= 58.00

RFI	U	N	TL	UP	UR	T1	T2	T3	AREA
.600	.220	.400	.270	3.330	.129	.300	.500	2.900	1.001

ADJUSTED HYDROGRAPH PARAMETERS

UP	UR	T1	T2	T3	AREA
3.327	.129	.300	.500	2.900	1.000

TABLE II. HYDROGRAPH OUTPUT

OBSERVED FLOW OUT OF WATERSHED (CFS)	PREDICTED FLOW OUT OF WATERSHED (CFS)	TIME (HOURS)	SUSPENDED SOLIDS DISCHARGED FROM WATERSHED LBS/SEC
0.000	0.000	0.000	0.000
0.000	0.000	.100	0.000
0.000	0.000	.200	0.000
0.000	0.000	.300	0.000
0.000	0.000	.400	0.000
0.000	0.000	.500	0.000
0.000	0.000	.600	0.000
0.000	0.000	.700	0.000
0.000	0.000	.800	0.000
0.000	0.000	.900	0.000
0.000	0.000	1.000	0.000
0.000	0.000	1.100	0.000
0.000	0.000	1.200	0.000
0.000	0.000	1.300	0.000
0.000	0.000	1.400	0.000
0.000	0.000	1.500	0.000
0.000	0.000	1.600	0.000
0.000	0.000	1.700	0.000
0.000	0.000	1.800	0.000
0.000	0.000	1.900	0.000
0.000	0.000	2.000	0.000
0.000	0.000	2.100	0.000
0.000	0.000	2.200	0.000
0.000	0.000	2.300	0.000
0.000	0.000	2.400	0.000
0.000	.045	2.500	.000
0.000	.423	2.600	.001
0.000	1.452	2.700	.004
0.000	3.326	2.800	.009
0.000	5.628	2.900	.016
0.000	7.932	3.000	.023
0.000	10.184	3.100	.029
0.000	12.384	3.200	.035
0.000	14.534	3.300	.041
0.000	16.636	3.400	.047
0.000	18.690	3.500	.053
0.000	20.698	3.600	.059
0.000	22.659	3.700	.064
0.000	24.576	3.800	.070
0.000	26.449	3.900	.075
0.000	28.278	4.000	.080
0.000	30.064	4.100	.085
0.000	31.807	4.200	.090
0.000	33.509	4.300	.095
0.000	35.169	4.400	.100
0.000	36.787	4.500	.104
0.000	38.365	4.600	.109
0.000	39.901	4.700	.113
0.000	41.398	4.800	.117
0.000	42.853	4.900	.122
0.000	44.269	5.000	.126
0.000	45.644	5.100	.129
0.000	46.980	5.200	.133
0.000	48.275	5.300	.137
0.000	49.531	5.400	.141
0.000	50.749	5.500	.144

0.000	51.930	5.600	.147
0.000	53.075	5.700	.151
0.000	54.187	5.800	.154
0.000	55.266	5.900	.157
0.000	56.314	6.000	.160
0.000	57.332	6.100	.163
0.000	58.321	6.200	.165
0.000	59.282	6.300	.168
0.000	60.217	6.400	.171
0.000	61.125	6.500	.173
0.000	62.009	6.600	.176
0.000	62.869	6.700	.178
0.000	63.705	6.800	.181
0.000	64.520	6.900	.183
0.000	65.313	7.000	.185
0.000	69.922	7.100	.198
0.000	78.443	7.200	.223
0.000	90.962	7.300	.258
0.000	98.196	7.400	.279
0.000	99.998	7.500	.284
0.000	101.745	7.600	.289
0.000	99.296	7.700	.282
0.000	92.577	7.800	.263
0.000	81.518	7.900	.231
0.000	76.166	8.000	.216
0.000	76.637	8.100	.217
0.000	77.093	8.200	.219
0.000	77.535	8.300	.220
0.000	77.963	8.400	.221
0.000	78.378	8.500	.222
0.000	78.780	8.600	.224
0.000	79.169	8.700	.225
0.000	79.546	8.800	.226
0.000	79.911	8.900	.227
0.000	80.264	9.000	.228
0.000	80.606	9.100	.229
0.000	80.937	9.200	.230
0.000	81.258	9.300	.231
0.000	81.568	9.400	.231
0.000	81.868	9.500	.232
0.000	82.158	9.600	.233
0.000	82.439	9.700	.234
0.000	78.070	9.800	.221
0.000	69.023	9.900	.196
0.000	55.288	10.000	.157
0.000	48.170	10.100	.137
0.000	47.711	10.200	.135
0.000	47.289	10.300	.134
0.000	46.903	10.400	.133
0.000	46.554	10.500	.132
0.000	46.223	10.600	.131
0.000	45.910	10.700	.130
0.000	45.616	10.800	.129
0.000	45.340	10.900	.129
0.000	45.083	11.000	.128
0.000	44.845	11.100	.127
0.000	44.626	11.200	.127
0.000	44.426	11.300	.126
0.000	44.246	11.400	.126
0.000	44.086	11.500	.125
0.000	43.946	11.600	.125
0.000	43.826	11.700	.124
0.000	38.918	11.800	.110
0.000	29.213	11.900	.083
0.000	14.705	12.000	.042
0.000	7.127	12.100	.020
0.000	6.490	12.200	.018
0.000	5.897	12.300	.017
0.000	5.349	12.400	.015
0.000	4.845	12.500	.014

0.000	4.387	12.600	.012
0.000	3.950	12.700	.011
0.000	3.537	12.800	.010
0.000	3.146	12.900	.009
0.000	2.777	13.000	.008
0.000	2.432	13.100	.007
0.000	2.109	13.200	.006
0.000	1.809	13.300	.005
0.000	1.531	13.400	.004
0.000	1.277	13.500	.004
0.000	1.045	13.600	.003
0.000	.837	13.700	.002
0.000	.651	13.800	.002
0.000	.489	13.900	.001
0.000	.349	14.000	.001
0.000	.233	14.100	.001
0.000	.140	14.200	.000
0.000	.070	14.300	.000
0.000	.023	14.400	.000
0.000	0.000	14.500	0.000

TOTAL SUSPENDED SOLIDS (LBS) DISCHARGED FROM WATERSHED
DURING STORM EVENT = 5188.523

FE CONC (PPM) 6.80680
FE LOAD (LBS) 775.87097

MN CONC (PPM) .88400
MN LOAD (LBS) 100.76246

CA CONC (PPM) 10.82900
CA LOAD (LBS) 1234.34018

MG CONC (PPM) .14277
MG LOAD (LBS) 16.27314

SO4 CONC (PPM) 5.48080
SO4 LOAD (LBS) 624.72727

ALK CONC (PPM) 29.65820
ALK LOAD (LBS) 3380.58065

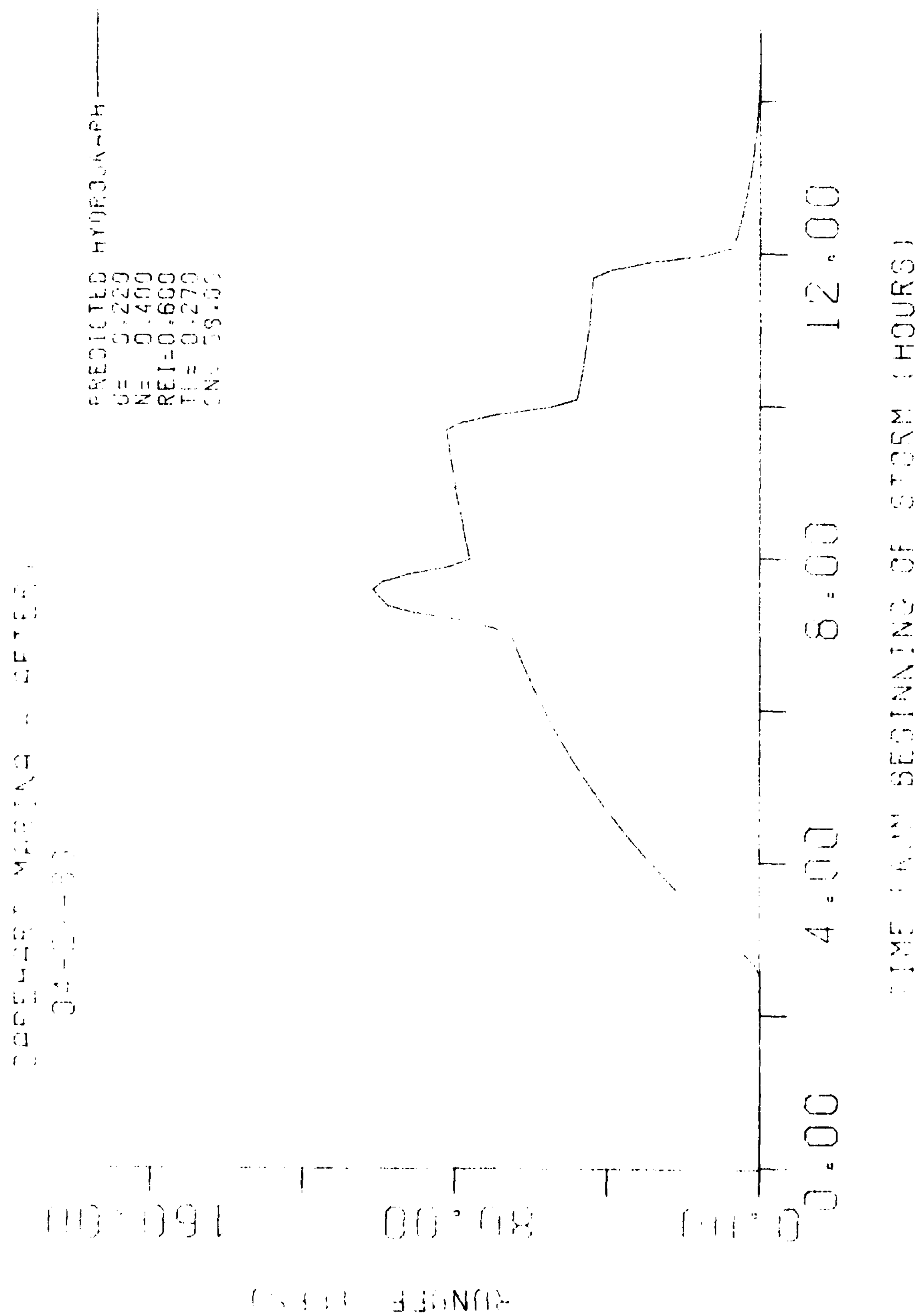
OPTIMIZED CURVE NUMBER = 0.0

TOTAL RUNOFF= 4.6306INCHES

KUP	KT1	KT2	KUR
.900	.956	1.800	.035

U	N	DT
.220	.400	.10000

SIMULATED LOAD MODULUS(LBS/AC-IN OF RUNOFF)
10.30



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3. Betson, R.P., Urban Hydrology - A Systems Study in Knoxville, Tennessee, TVA, Division of Water Management, 1976.

4. Overton, D.E., W.L. Troxler and E.C. Crosby, "Simulation of Effects of Urbanization of Stormwater Runoff and Quality," Univ. of Tennessee, Water Resource Center, Report No. 74, December 1979.

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APPENDIX A

LISTING OF AFRUM

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74/74   OPT=1   FTN 4.8+518   10/06/80 09.37.33

```
      PROGRAM AFRUM (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,TAPE9)        AFRUM     2
C                                                                              AFRUM     3
C                                                                              AFRUM     4
C                                                                              AFRUM     5
C******************************************************************************AFRUM     6
C******************************************************************************AFRUM     7
C**********                                                         ***********AFRUM     8
C**********            U.S. AIR FORCE RUNOFF MODEL (AFRUM)          ***********AFRUM     9
C**********                                                         ***********AFRUM    10
C**********      A STORM HYDROGRAPH SIMULATION MODEL DEVELOPED FOR  ***********AFRUM    11
C**********      THE AIR FORCE ENGINEERING SERVICES CENTER, TYNDALL ***********AFRUM    12
C**********      AFB, FLORIDA BY DR DONALD OVERTON OF THE UNIVERSITY***********AFRUM    13
C**********      OF TENNESSEE, PRINCIPAL INVESTIGATOR AND GEORGE W. ***********AFRUM    14
C**********      SCHLOSSNAGLE, CAPT USAF BSC, PROJECT OFFICER       ***********AFRUM    15
C**********                                                         ***********AFRUM    16
C*******************************************************************          AFRUM    17
C******************************************************************************AFRUM    18
C**********                 USER INPUT INSTRUCTIONS                 ***********AFRUM    19
C******************************************************************************AFRUM    20
C                                                                              AFRUM    21
C                                  AFRUM                                       AFRUM    22
C                                                                              AFRUM    23
C     CARD     FORMAT/         VARIABLE NAMES AND DESCRIPTION                  AFRUM    24
C     NO.      COLUMNS                                                         AFRUM    25
C     1         (12A1)         BANNER PAGE - 1ST LINE -- USER DESCRIPTION      AFRUM    26
C               (1-12)                                                         AFRUM    27
C     2         (12A1)         BANNER PAGE - 2ND LINE -- USER DESCRIPTION      AFRUM    28
C               (1-12)                                                         AFRUM    29
C     3         (12A1)         BANNER PAGE - 3RD LINE -- USER DESCRIPTION      AFRUM    30
C               (1-12)                                                         AFRUM    31
C    4         (12A1)          BANNER PAGE - 4TH LINE -- USER DESCRIPTION      AFRUM    32
C               (1-12)                                                         AFRUM    33
C                                                                              AFRUM    34
C                                                                              AFRUM    35
C                                                                              AFRUM    36
C     5         (20A4)         TITLE                                           AFRUM    37
C               (1-80)         NAME AND LOCATION OF WATERSHED                  AFRUM    38
C                                                                              AFRUM    39
C     6         (6I4)          ISIM,IUNIT,IPLOT,ICHAR,ILAG,ILOAD               AFRUM    40
C                1-4           ISIM-A CONTROL VARIABLE TO SPECIFY THE TYPE OF  AFRUM    41
C                              DATA SUPPLIED TO THE PROGRAM                    AFRUM    42
C                              ISIM=1   ONLY RAINFALL DATA IS SUPPLIED AND AN  AFRUM    43
C                                        ESTIMATE MUST BE MADE OF THE SCS CURVE AFRUM   44
C                                        NUMBER                                AFRUM    45
C                              ISIM=0   RAINFALL AND RUNOFF DATA IS SUPPLIED AND AFRUM  46
C                                        SCS CURVE NUMBER IS OPTIMIZED TO MAKE AFRUM    47
C                                        RUNOFF EQUAL TO PRECIPITATION EXCESS  AFRUM    48
C                5-8           IUNIT- A CONTROL PARAMETER TO SPECIFY OUTPUT UNITS AFRUM 49
C                                     OF SIMULATED HYDROGRAPH                  AFRUM    50
C                              IUNIT=0  UNITS ARE IN INCHES/HR                 AFRUM    51
C                              IUNIT=1  UNITS ARE IN CFS                       AFRUM    52
C                9-12          IPLOT- A CONTROL PARAMETER TO DETERMINE IF OUTPUT AFRUM  53
C                                     IS PLOTTED                               AFRUM    54
C                              IPLOT=0  NO PLOT IS PRODUCED                    AFRUM    55
C                              IPLOT=1  A PLOT IS PRODUCED                     AFRUM    56
C               13-16          ICHAR- A CONTROL PARAMETER TO SPECIFY IF        AFRUM    57
C                                     LAND USE IS URBAN(WITH OR WITHOUT        AFRUM    58
C                                     EXTENSIVE STORM SEWERS), AGRICULTURAL,   AFRUM    59
C                                     COAL STRIP MINED, OR 100% FOREST         AFRUM    60
C                              ICHAR=0  URBAN WITHOUT STORM SEWERS             AFRUM    61
C                              ICHAR=1  URBAN WITH STORM SEWERS                AFRUM    62
C                              ICHAR=2  COAL STRIP MINED                       AFRUM    63
C                              ICHAR=3  AGRICULTURAL                           AFRUM    64
C                              ICHAR=4  FORESTED                               AFRUM    65
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C              17-20           ILAG- A CONTROL PARAMETER TO DETERMINE IF LAG       AFRUM   66
C                                    MODULUS IS READ IN OR SIMULATED FROM          AFRUM   67
C                                    WATERSHED CHARACTERISTICS                     AFRUM   68
C                                                                                  AFRUM   69
C                              ILAG=0  LAG MODULUS IS READ IN                      AFRUM   70
C                              ILAG=1  LAG MODULUS IS SIMULATED FROM URBAN         AFRUM   71
C                                      WATERSHED CHARACTERISTICS(% IMPERVIOUS      AFRUM   72
C                                      AND AREA(SQMI))                             AFRUM   73
C                              ILAG=2  LAG MODULUS IS SIMULATED FROM RURAL         AFRUM   74
C                                      WATERSHED CHARACTERISTICS(% FOREST          AFRUM   75
C                                      AND AREA(SQMI))                             AFRUM   76
C              21-24           ILOAD- A CONTROL PARAMETER TO DETERMINE HOW         AFRUM   77
C                                     SUSPENDED SEDIMENT STORM LOAD IS TO BE       AFRUM   78
C                                     SIMULATED FROM % FOREST, % IMPERVIOUS,       AFRUM   79
C                                     % STRIPPED AND LAG MODULUS                   AFRUM   80
C                              ILOAD=1  URBAN WATERSHED                            AFRUM   81
C                              ILOAD=2  COAL STRIP MINED WATERSHED                 AFRUM   82
C                                                                                  AFRUM   83
C     WATERSHED CHARACTERISTICS:IF URBAN,PS=0;IF RURAL,PI=0                        AFRUM   84
C      7       (4F8.0)         SQMI,PF,PS,PI                                       AFRUM   85
C                                                                                  AFRUM   86
C              (1-8)           SQMI= WATERSHED AREA IN SQUARE MILES                AFRUM   87
C              (9-16)          PF=PERCENT FOREST                                   AFRUM   88
C              (17-24)         PS=PERCENT COAL STRIP MINED(OR DENUDED)             AFRUM   89
C              (25-32)         PI=PERCENT IMPERVIOUS                               AFRUM   90
C                                                                                  AFRUM   91
C                                                                                  AFRUM   92
C      CARD 8 IS NOT REQUIRED IF ISIM=0 (CARD 5)                                   AFRUM   93
C                                                                                  AFRUM   94
C      8       (F10.0)        CN                                                   AFRUM   95
C              (1-10)          CN= SCS CURVE NUMBER FOR WATERSHED AT THE TIME THE  AFRUM   96
C                                  STORM OCCURED (VARIES WITH ANTECEDENT MOISTURE) AFRUM   97
C                                                                                  AFRUM   98
C                                                                                  AFRUM   99
C      CARD 9 IS NOT REQUIRED IF ILAG=1 OR 2 (CARD 5)                              AFRUM  100
C      9       (F10.0)         U                                                   AFRUM  101
C              (1-10)          U=LAG MODULUS, HOURS                                AFRUM  102
C                                                                                  AFRUM  103
C                                                                                  AFRUM  104
C     10       (F10.0)         DT                                                  AFRUM  105
C              (1-10)          DT= TIME INTERVAL USED IN ABSTRACTING RAINFALL(HRS) AFRUM  106
C                                                                                  AFRUM  107
C      CARDS 11,12, AND 13 MUST BE REPEATED FOR EACH STORM TO BE SIMULATED         AFRUM  108
C                                                                                  AFRUM  109
C                                                                                  AFRUM  110
C     11       (8A4)           BASIN                                               AFRUM  111
C              (1-32)          BASIN= NAME OF WATERSHED                            AFRUM  112
C                                                                                  AFRUM  113
C                                                                                  AFRUM  114
C     12       (2A4)           BDATE                                               AFRUM  115
C                              BDATE= DATE OF STORM                                AFRUM  116
C                                                                                  AFRUM  117
C     13       (I1,9X,F10.3,   ISTAGE,RAIN(I),SFLOW(I)                             AFRUM  118
C              30X,F10.3)                                                          AFRUM  119
C               (1)            ISTAGE- A CONTROL PARAMETER TO SIGNAL THE END OF A  AFRUM  120
C                                      STORM DATA SET                              AFRUM  121
C                              ISTAGE=0  SIGNALS CONTINUATION OF RAINFALL/RUNOFF   AFRUM  122
C                              ISTAGE=1  SIGNALS LAST DATA CARD OF A STORM         AFRUM  123
C              (2-10)          BLANK                                               AFRUM  124
C             (11-20)          RAIN(I)                                             AFRUM  125
C                              RAIN(I)=  CUMULATIVE STORM RAINFALL ABSTRACTED AT   AFRUM  126
C                                        DT TIME INTERVALS. THE FIRST VALUE OF     AFRUM  127
C                                        RAIN(I) MUST BE 0.0 AT TIME 0.0           AFRUM  128
C             (21-50)          BLANK                                               AFRUM  129
C             (51-60)          SFLOW(I)                                            AFRUM  130
C                              SFLOW(I)=  STORMWATER DISCHARGE IN CFS,             AFRUM  131
C                                         ABSTRACTED AT DT TIME INTERVALS.         AFRUM  132
C                                         VALUES OF SFLOW(I) ARE NOT REQUIRED      AFRUM  133
C                                         IF ISIM=1 (CARD 1). THE FIRST AND        AFRUM  134
C                                         LAST VALUES OF SFLOW(I) MUST BE 0.0      AFRUM  135
```

```
C
C
C     NO. OF RAINFALL/RUNOFF CARDS MUST BE EQUAL TO NUMBER OF RAINFALL/RUNOFF
C     OBSERVATIONS
C     A MAXIMUM OF 500 RAINFALL/RUNOFF OBSERVATIONS MAY BE SUBMITTED
C
C
C*************************************************************************
C
C
      REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR
      COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)
     >,ARF(500),RF(500),PEI(500),PE(500),SRO(500),BASIN(4),BDATE,
     >IAREA(664),PHI,DT,U,T1,T2,T3,UP,UR,REI,KT1,KT2,KUP,RN,ITOTAL,
     >ICRASH,IDMAX,NPRF,UHYDRO(800),NPRO,CNOPT,NBIG,TL,KT23
     >,TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)
     >,DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TPOB,TPPR,ISIM
     >,IPLOT,IUNIT,NPRF1,NPRF2,AREA,KUR
     >,TITLE(20),SQMI,SHAPE,SC,DD,SINU,CNA,SS,IMP,TLP
     <,ILOAD,DLOAD
C
C     THE FOLLOWING DATA CARDS CONTAIN COEFFICIENTS FOR SIMULATING LAG MODULUS,
C     UP,T1,T2,AND T23 US A FUNCTION OF WATERSHED CHARACTERISTICS.
C     THESE REGIONALIZED COEFFICIENTS WERE DERIVED BY USING BMDP4R (LINEAR
C     REGRESSION UPON PRINCIPAL COMPONENTS).
C     THESE COEFFICIENTS ARE SUBJECT TO REVISION AS MORE DATA BECOMES AVAILABLE
C
      DATA C1,C2,C3,C4,C5,C6,C7,C8,C9,C10/ -8.4076,0.0133,0.5126,0.0001,
     >-0.0635,7.2776,0.0333,0.07944,1.7401,-2.05101/
      DATA C11,C12,C13,C14,C15,C16,C17,C18,C19,C20/ 0.4466,0.0019,-0.015
     >1,-0.0001,-0.0066,-0.0372,0.0007,0.00182,0.22134,0.07726/
      DATA C21,C22,C23,C24,C25,C26,C27,C28,C29,C30/ 0.2989,0.0066,-0.058
     >9,-0.0002,0.0127,-0.2129,-0.0031,0.00176,0.34552,-0.4254/
      DATA C31,C32,C33,C34,C35,C36,C37,C38,C39,C40/ 0.7712,0.0063,-0.040
     >1,0.000,0.0264,0.3054,-0.0018,0.01398,-0.36460,-0.7373/
      DATA C41,C42,C43,C44,C45,C46,C47,C48,C49,C50/ -3.9713,-0.0208,.394
     >8,0.0,-0.0156,1.9912,0.0051,0.02849,2.7258,1.18497/
      CALL PLOTS(0.,0.,9)
C
      CALL PLOT(0.0,1.5,-3)
C     PRINTS BANNER ( FIRST 4 CRDS)
C
      CALL LETTER
C
      CALL AESOP
C
C
C     IDMAX=MAXIMUM DIMENSION OF MATRIX HYDRO
      IDMAX=800
C
C
C     READ WATERSHED LOCATION AND NAME  (CARD 1)
C
      READ(5,9) TITLE
    9 FORMAT(20A4)
   10 FORMAT (4A10)
C
C     READ PROGRAM CONTROL PARAMETERS  (CARD 2)
C
      READ(5,12) ISIM,IUNIT,IPLOT,ICHAR,ILAG,ILOAD
   12 FORMAT(6I4)
C
C     READ WATERSHED PHYSICAL CHARACTERISTICS  (CARD 3)
C
      READ(5,14) SQMI,PF,PS,PI
   14 FORMAT(4F8.2)
      IF(ISIM .EQ.0) GO TO 16
C
C     READ SCS CURVE NUMBER  (CARD 4)
C
      READ(5,15) CN
   15 FORMAT(F10.0)
```

```
16    CONTINUE
      RN=.4
C
C     READ LAG MODULUS  (CARD 5)
C
      IF (ILAG .GT. 0) GO TO 20
      READ(5,15) U
      GO TO 23
20    IF (ILAG .EQ. 1) GO TO 22
      U=(0.060*SQMI) + (0.0203*PF) + 1.16
      IF (U .GE. 0.0) GO TO 23
      WRITE(6,520)
520   FORMAT(5X,"NEGATIVE VALUE OF LAGMODULUS SIMULATED,PROGRAM STOPPED
     >"//)
      IQUIT=1
      GO TO 23
22    U=3.24*(SQMI/PI)**0.6
      IF (U .GE. 0.0) GO TO 23
      WRITE(6,21)
21    FORMAT(5X,"NEGATIVE VALUE OF LAGMODULUS SIMULATED,PROGRAM STOPPED
     >"//)
      IQUIT=1
23    CONTINUE
C
C     DEFINE NORMALIZED UNIT RESPONSE FUNCTION
C
      IF (ICHAR .GT. 0) GO TO 24
      KUP=0.663
      KT1=0.632
      KT2=1.88
      KUR=0.12
      GO TO 30
24    IF (ICHAR .GT. 1) GO TO 25
      KUP=0.900
      KT1=0.956
      KT2=1.80
      KUR=0.035
      GO TO 30
25    IF (ICHAR .GT. 2) GO TO 26
      KUP=0.740
      KT1=0.253
      KT2=1.085
      KUR=0.21
      GO TO 30
26    IF (ICHAR .GT. 3) GO TO 27
      KUP=0.705
      KT1=0.695
      KT2=1.87
      KUR=0.13
      GO TO 30
27    KUP=0.716
      KT1=0.394
      KT2=1.57
      KUR=0.10
30    CONTINUE
C
C     READ TIME INTERVAL (CARD 6)
C
      READ(5,15) DT
      IF (ILOAD .EQ. 1) DLOAD=16.7*PS-21.5*U*PF+62.3
      IF(ILOAD .EQ. 2) DLOAD=18.17*PS-1.28*U*PF+527.67
      IF (DLOAD .GT. 0.0)  GO TO 36
      DLOAD = 0.0
      WRITE (6,31)
31    FORMAT (1H ,///,12X,"WARNING:  EQUATIONS PREDICT MORE SEDIMENT CAN
```

```
     . BE DEPOSITED",/,12X,"THAN CAN BE PICKED UP; THEREFORE, LOAD MODUL
     .US IS SET EQUAL TO ZERO.",///)
C
C     READ BASIN NAME (CARD 7)
C
 36   READ(5,10) BASIN
      IF(EOF(5)) 480,35
 35   CONTINUE
C
C     READ DATE OF STORM (CARD 8)
C
      READ(5,37) BDATE
 37   FORMAT (A8)
      WRITE (6,11) TITLE
 11   FORMAT (15(/),46X,20A4,//)
C
      CALL BASINA(SQMI,PF,PS,BDATE,BASIN,PI)
C
      CALL ASSUME(ISIM,IPHI,IUNIT,IPLOT,ICHAR,ILAG,ILOAD)
C
      IF (IQUIT .EQ. 1) GO TO 50
      GO TO 51
 50   CONTINUE
      GO TO 480
 51   CONTINUE
      I=1
      NPRO=0
      NPRF=1
      RMAX=0.0
      IPHI=0
C
C     READ OBSERVED RAINFALL AND DISCHARGE  (CARD 9)
C
 55   READ(5,60) ISTAGE,RAIN(I),SFLOW(I)
 60   FORMAT(I1,9X,F10.3,30X,F10.3)
      TIME(I)=DT*I-DT
      IF(RAIN(I) .GT. RMAX) RMAX=RAIN(I)
      IF(I .GT. 1) GO TO 62
      RF(I)=0.0
      GO TO 70
 62   RF(I)=RAIN(I)-RAIN(I-1)
      IF (RF(I) .LT. 0.0) RF(I)=0.0
 70   CONTINUE
C     INCHES OF RUNOFF=((FLOW(CFS)/AREA(FT**2))*3600SEC/HR*12.0IN/FT
      RNOFF(I)=(SFLOW(I)/(SQMI*640.0*43560.0))*3600.0*12.0
      IF(RAIN(I) .GT. 0.0) NPRF=NPRF+1
      NPRO=NPRO+1
      IF(ISTAGE .GE. 1) GO TO 100
      I=I+1
      GO TO 55
 100  CONTINUE
      WRITE (6,103)
 103  FORMAT(1H ,15X,"TABLE I.  USER INPUT",///)
      WRITE(6,105)
 105  FORMAT(36X,"OBSERVED DATA"/5X,"TIME",6X,"TOTAL",2X,"INCREMENTAL",
     .2X,"FLOW",6X,"FLOW"/5X,"(HR)",6X,"RAIN",6X,"RAIN",5X,"(CFS)",5X,
     .   "(IN/HR)"/15X,"(IN)",6X,"(IN)",//)
      IF (ISIM .EQ. 1) NPRO=0
      NDIM=NPRO
      IF (NPRF .GT. NDIM) NDIM=NPRF
      IF (ISIM .EQ. 0) GO TO 1080
      DO 108 I=1,500
      SFLOW(I)=0.0
      RNOFF(I)=0.0
 108  CONTINUE
 1080 CONTINUE
      DO 115 I=1,NDIM
      WRITE(6,110) TIME(I),RAIN(I),RF(I),SFLOW(I),RNOFF(I)
 110  FORMAT (4F10.2,F10.5)
 115  CONTINUE
```

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      IF (ISIM .EQ. 1) PHI=0.0
      IF (ISIM .EQ. 1) GO TO 290
      TRUN=0.0
      DO 160 I=1,NPRO
      TRUN=TRUN+RNOFF(I)
  160 CONTINUE
      TRUN=TRUN*DT
      IF(TRUN .LE. RAIN(NPRF)) GO TO 165
      WRITE(6,162)
  162 FORMAT(1X,"APPARENT ERROR IN DATA, RUNOFF EXCEEDS RAINFALL"/
     >5X,"POSSIBLE CAUSE",25X,"CORRECTIVE ACTION"/
     >1X,"(1)",2X,"NONUNIFORM RAINFALL DISTRIBUTION",7X,"DISCARD DATA"/
     >1X,"(2)",2X,"ESTIMATE OF CN IS TOO LARGE",12X,"REDUCE INPUT CN"//)
      GO TO 460
  165 LOSS=RMAX-TRUN
      RFINT=RMAX/((NPRF-1)*DT)
      CNL=10.0
      CNR=100.0
  185 CNM=(CNL+CNR)/2.0
      CALL SCS(CNL)
      PRUNL=SRO(NPRF)
      CALL SCS(CNR)
      PRUNR=SRO(NPRF)
      CALL SCS(CNM)
      PRUNM=SRO(NPRF)
      DP=PRUNM-TRUN
      IF (DP-0.0) 240,270,220
  220 CNR=CNM
      GO TO 250
  240 CNL=CNM
  250 ABDP=ABS(DP)
C     IF THE DIFFERENCE IN THE OBSERVED AND PREDICTED RUNOFF VOLUMES IS LESS
C     THAN 1%, STOP ITERATIONS
      IF (ABDP .LE. 0.01*TRUN) GO TO 270
  260 GO TO 185
  270 CONTINUE
      CN=CNM
  290 CNOPT=CN
      IF (ISIM .EQ. 0) GO TO 295
      WRITE(6,292) CN
  292 FORMAT (////,5X,"ESTIMATED CN=",F6.2,//)
  295 CALL SCS(CN)
      SSQPE=0.0
      SUMPE=0.0
      DO 360 I=1,NPRF
      SUMPE=PEI(I)+SUMPE
      SSQPE=(PEI(I)**2.0)+SSQPE
  360 CONTINUE
      REI=SSQPE/SUMPE
      WRITE (6,361)
  361 FORMAT (1H ,/////)
      CALL SIMLAT
      IF (ICRASH .EQ. 1) GO TO 460
      CALL CONVOL
      WRITE (6,362)
  362 FORMAT (1H ,///)
      IF (ISIM .EQ. 0) GO TO 375
      WRITE(6,280) CNM
  280 FORMAT (//,5X,"OPTIMIZED CURVE NUMBER = ",F15.1,/)
      WRITE(6,380) SRO(NPRF)
  380 FORMAT(5X,"TOTAL RUNOFF=",F8.4,"INCHES"//)
  375 CONTINUE
      WRITE(6,45) KUP,KT1,KT2,KUR,U,RN,DT
   45 FORMAT(1H ,//,
     .6X,"KUP",7X,"KT1",7X,"KT2",7X,"KUR ",/,4F10.3,//
     .7X,"U",7X,"N",8X,"DT",/,F10.3,F8.3,F10.5,//)
      WRITE (6,38) DLOAD
   38 FORMAT(//5X,"SIMULATED LOAD MODULUS(LBS/AC-IN OF RUNOFF)"/F13.2)
      IF (ICRASH .EQ. 1) GO TO 460
      IF (IPLOT .EQ. 0) GO TO 400
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```
      CALL HYPLOT                                                        AFRUM  411
  400 CONTINUE                                                           AFRUM  412
      ISKIP=1                                                            AFRUM  413
      IF(ISKIP .EQ. 1) GO TO 460                                         AFRUM  414
  405 WRITE(6,410)                                                       AFRUM  415
  410 FORMAT("1")                                                        AFRUM  416
      WRITE(7,420) BASIN, BDATE                                          AFRUM  417
  420 FORMAT(8A4,2A4)                                                    AFRUM  418
      WRITE(7,440)         RMAX,TIME(NPRF),TRUN,CN,OBPEAK,PRPEAK,TPOB,TPPR  AFRUM  419
  440 FORMAT(8F10.5)                                                     AFRUM  420
      WRITE(7,450) UP,UR,T1,T2,T3,REI                                    AFRUM  421
  450 FORMAT(6F10.3)                                                     AFRUM  422
  460 CONTINUE                                                           AFRUM  423
      GO TO 36                                                           AFRUM  424
  480 CONTINUE                                                           AFRUM  425
      CALL PLOT(14.0,0.0,-3)                                             AFRUM  426
      CALL PLOT(0.0,0.0,999)                                             AFRUM  427
      STOP                                                               AFRUM  428
      END                                                                AFRUM  429
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SUBROUTINE SCS        74/74    OPT=1                         FTN 4.8+518        10/06/80  09.37.33

          C                                                                    AFRUM  430
          C                                                                    AFRUM  431
                SUBROUTINE SCS(CN)                                             AFRUM  432
          C                                                                    AFRUM  433
          C     THIS SUBROUTINE COMPUTES AND DISTRIBUTES EXCESS PRECIPITATION  AFRUM  434
          C                                                                    AFRUM  435
          C                                                                    AFRUM  436
                REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR                             AFRUM  437
                COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)  AFRUM  438
               >,ARF(500),RF(500),PEI(500),PE(500),SRO(500),BASIN(4),BDATE,   AFRUM  439
               >IAREA(664),PHI,DT,U,T1,T2,T3,UP,UR,REI,KT1,KT2,KUP,RN,ITOTAL, AFRUM  440
               >ICRASH,IDMAX,NPRF,UHYDRO(800),NPRO,CNOPT,NBIG,TL,KT23          AFRUM  441
               >,TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)      AFRUM  442
               >,DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TPOB,TPPR,ISIM            AFRUM  443
               >,IPLOT,IUNIT,NPRF1,NPRF2,AREA,KUR                             AFRUM  444
               >,TITLE(20),QMI,SHAPE,SC,DD,SINU,CNA,SS,IMP,TLP                AFRUM  445
               <,ILOAD,DLO                                                     AFRUM  446
                S=(1000.0/CN)-10.0                                             AFRUM  447
                DO 120 I=1,NPRF                                                AFRUM  448
                IF(I .EQ. 1) GO TO 60                                          AFRUM  449
                GO TO 100                                                      AFRUM  450
          60    IF (RF(I) .GT. PHI) ARF(I)=RF(I)-PHI                           AFRUM  451
                IF(RF(I) .LE. PHI) ARF(I)=0.0                                  AFRUM  452
          65    IF(ARF(I) .GT. 0.2*S)   GO TO 70                               AFRUM  453
                GO TO 75                                                       AFRUM  454
          70    SRO(I)=((ARF(I)-0.2*S)**2.0)/(ARF(I)+0.8*S)                    AFRUM  455
                GO TO 80                                                       AFRUM  456
          75    SRO(I)=0.0                                                     AFRUM  457
          80    PE(I)=SRO(I)                                                   AFRUM  458
                PEI(I)=PE(I)/DT                                                AFRUM  459
                GO TO 120                                                      AFRUM  460
          100   IF (RF(I) .GT. PHI) ARF(I)=ARF(I-1)+RF(I)-PHI                  AFRUM  461
                IF(RF(I) .LE. PHI) ARF(I)=ARF(I-1)                             AFRUM  462
          105   IF(ARF(I) .GT. 0.2*S) GO TO 110                                AFRUM  463
                SRO(I)=SRO(I-1)                                                AFRUM  464
                GO TO 115                                                      AFRUM  465
          110   SRO(I)=((ARF(I)-0.2*S)**2.0)/(ARF(I)+0.8*S)                    AFRUM  466
          115   PE(I)=SRO(I)-SRO(I-1)                                          AFRUM  467
                PEI(I)=PE(I)/DT                                                AFRUM  468
          C     DELETE VERY SMALL VALUES OF PEI                                AFRUM  469
                IF (PEI(I) .GT. .001) GO TO 120                                AFRUM  470
                PEI(I)=0.0                                                     AFRUM  471
          120   CONTINUE                                                       AFRUM  472
                RETURN                                                         AFRUM  473
                END                                                            AFRUM  474
```

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      C                                                                  AFRUM  475
      C                                                                  AFRUM  476
            SUBROUTINE SIMLAT                                            AFRUM  477
      C                                                                  AFRUM  478
      C     THIS SUBROUTINE IS A SIMULATION PROCEDURE FOR THE PARAMETERS AFRUM  479
      C     OF THE TVA DOUBLE TRIANGLE MODEL                             AFRUM  480
      C                                                                  AFRUM  481
      C                                                                  AFRUM  482
            REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR                           AFRUM  483
            COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500) AFRUM  484
           >,ARF(500),RF(500),PEI(500),PE(500),SRO(500),BASIN(4),BDATE,  AFRUM  485
           >IAREA(664),PHI,DT,U,T1,T2,T3,UP,UR,REI,KT1,KT2,KUP,RN,ITOTAL, AFRUM  486
           >ICRASH,IDMAX,NPRF,UHYDRO(800),NPRO,CNOPT,NBIG,TL,KT23        AFRUM  487
           >,TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)     AFRUM  488
           >,DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TPOB,TPPR,ISIM           AFRUM  489
           >,IPLOT,IUNIT,NPRF1,NPRF2,AREA,KUR                            AFRUM  490
           >,TITLE(20),SQMI,SHAPE,SC,DD,SINU,CNA,SS,IMP,TLP              AFRUM  491
           <,ILOAD,DLOAD                                                 AFRUM  492
      C     ICRASH IS A CONTROL PARAMETER TO SIGNIFY THAT THE DATA IS INCOMPATABLE AFRUM  493
      C     WITH THE MODEL BEING USED                                    AFRUM  494
            ICRASH =0                                                    AFRUM  495
      C     CALCULATE TL                                                 AFRUM  496
            TL=U/(REI**RN)                                               AFRUM  497
      C     CALCULATE UP,T1,T2                                           AFRUM  498
            UP=KUP/TL                                                    AFRUM  499
            T1=KT1*TL                                                    AFRUM  500
            CALL ADJUST(T1,DT)                                           AFRUM  501
            T2=KT2*TL                                                    AFRUM  502
            CALL ADJUST(T2,DT)                                           AFRUM  503
            IF (T2 .LE. T1) T2 = T1+DT                                   AFRUM  504
      C     CALCULATE UR AND T3                                          AFRUM  505
            UR=KUR/TL                                                    AFRUM  506
            T3 = T1+(2-T2*UP)/UR                                         AFRUM  507
      C     LIMIT T3 TO A REASONABLE VALUE                               AFRUM  508
            TL15=15.0*TL                                                 AFRUM  509
            IF (T3 .LT. TL15) GO TO 310                                  AFRUM  510
            T3=TL15                                                      AFRUM  511
        310 CALL ADJUST(T3,DT)                                           AFRUM  512
            IF (T3 .LE. T2) T3 = T2+DT                                   AFRUM  513
            AREA=(0.5*T1*UP)+(0.5*(UP+UR)*(T2-T1))+(0.5*UR*(T3-T2))      AFRUM  514
        320 WRITE(6,360) REI,U,RN,TL,UP,UR,T1,T2,T3,AREA                 AFRUM  515
        360 FORMAT(6X,"REI",8X,"U",9X,"N",8X,"TL",8X,"UP",8X,"UR",8X,"T1",8X," AFRUM  516
           >T2",8X,"T3",7X,"AREA"/10F10.3/)                              AFRUM  517
            UP=(1.0/AREA)*UP                                             AFRUM  518
            UR=(1.0/AREA)*UR                                             AFRUM  519
            AREA=(0.5*T1*UP)+(0.5*(UP+UR)*(T2-T1))+(0.5*UR*(T3-T2))      AFRUM  520
            WRITE(6,395)                                                 AFRUM  521
        395 FORMAT(10X,"ADJUSTED HYDROGRAPH PARAMETERS"/)                AFRUM  522
            WRITE(6,400) UP,UR,T1,T2,T3,AREA                             AFRUM  523
        400 FORMAT(6X,"UP",8X,"UR",8X,"T1",8X,"T2",8X,"T3",6X,"AREA"/6F10.3/// AFRUM  524
           >/)                                                           AFRUM  525
        430 RETURN                                                       AFRUM  526
            END                                                          AFRUM  527
```

SUBROUTINE ADJUST   74/74   OPT=1   FTN 4.8+518   10/06/80 09.37.33

```
      C                                                                 AFRUM  528
      C                                                                 AFRUM  529
            SUBROUTINE ADJUST(T,DT)                                     AFRUM  530
      C                                                                 AFRUM  531
      C     THIS SUBROUTINE ADJUSTS T1,T2,T3 TO THE NEAREST MULTIPLE OF DT AFRUM  532
      C                                                                 AFRUM  533
      C                                                                 AFRUM  534
            FDELTA=DT                                                   AFRUM  535
            DELTA=100.0*DT                                              AFRUM  536
            N=1                                                         AFRUM  537
      10    ADT=N*DELTA                                                 AFRUM  538
            IF(ADT .GE. T) GO TO 20                                     AFRUM  539
            N=N+1                                                       AFRUM  540
            GO TO 10                                                    AFRUM  541
      20    IF (DELTA .GT. FDELTA) GO TO 30                             AFRUM  542
            GO TO 50                                                    AFRUM  543
      30    DELTA=DELTA/10.0                                            AFRUM  544
            N=(N-1)/10                                                  AFRUM  545
            GO TO 10                                                    AFRUM  546
      50    ADTT=ADT -(FDELTA/2.0)                                      AFRUM  547
            IF (ADTT .GT. T) GO TO 60                                   AFRUM  548
            T=ADT                                                       AFRUM  549
            GO TO 70                                                    AFRUM  550
      60    T=DELTA*(N-1)                                               AFRUM  551
      70    RETURN                                                      AFRUM  552
            END                                                         AFRUM  553
```

```
      C                                                                    AFRUM  554
      C                                                                    AFRUM  555
            SUBROUTINE CONVOL                                              AFRUM  556
      C                                                                    AFRUM  557
      C                                                                    AFRUM  558
      C     THIS SUBROUTINE CALCULATES THE ORDINATES OF A CONVOLUTED HYDROGRAPH IF A  AFRUM  559
      C     UNIT HYDROGRAPH AND A PRECIPITATION EXCESS MATRIX ARE PROVIDED AS INPUT   AFRUM  560
      C                                                                    AFRUM  561
      C                                                                    AFRUM  562
            REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR,LFE,LMN,LCA,LMG,LSO,LAL     AFRUM  563
            COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)  AFRUM  564
           >,ARF(500),PF(500),PEI(500),PE(500),SRO(500),BASIN(4),BDATE,    AFRUM  565
           >IAREA(664),PHI,DT,U,T1,T2,T3,UP,UR,REI,KT1,KT2,KUP,RN,ITOTAL,  AFRUM  566
           >ICRASH,IDMAX,NPRF,UHYDRO(800),NPRO,CNOPT,NBIG,TL,KT23          AFRUM  567
           >,TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)       AFRUM  568
           >,DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TPOB,TPPR,ISIM             AFRUM  569
           >,IPLOT,IUNIT,NPRF1,NPRF2,AREA,KUR                              AFRUM  570
           >,TITLE(20),SOMI,SHAPE,SC,DD,SINU,CNA,SS,IMP,TLP                AFRUM  571
           <,ILOAD,DLOAD                                                   AFRUM  572
            COMMON /CAPT/ICHAR,PF,PI,PS                                    AFRUM  573
      C     COMPUTE NUMBER OF INCREMENTS IN EACH LIMB OF HYDROGRAPH (RISING,FALLING,  AFRUM  574
      C     AND RECESSION)                                                 AFRUM  575
            DELTA1=T1/DT                                                   AFRUM  576
            DELTA2=T2/DT                                                   AFRUM  577
            DELTA3=T3/DT                                                   AFRUM  578
      C     INPUT DUMMY PARAMETER TO USE IN CONTROLLING OUTPUT             AFRUM  579
      80    ISKIP=1                                                        AFRUM  580
            NPE=NPRF                                                       AFRUM  581
      C     COMPUTE NUMBER OF DT PERIODS IN EACH LIMB OF HYDROGRAPH (RISING,FALLING   AFRUM  582
      C     AND RECESSION                                                  AFRUM  583
            N1=0                                                           AFRUM  584
      90    N1=N1+1                                                        AFRUM  585
            IF (N1 .GT. DELTA1+0.1) GO TO 100                              AFRUM  586
            GO TO 90                                                       AFRUM  587
      100   N1=N1-1                                                        AFRUM  588
            N2=0                                                           AFRUM  589
      110   N2=N2+1                                                        AFRUM  590
            IF (N2 .GT. DELTA2+0.1) GO TO 120                              AFRUM  591
            GO TO 110                                                      AFRUM  592
      120   N2=N2-1                                                        AFRUM  593
            N3=0                                                           AFRUM  594
      130   N3=N3+1                                                        AFRUM  595
            IF (N3 .GT. DELTA3+0.1) GO TO 140                              AFRUM  596
            GO TO 130                                                      AFRUM  597
      140   N3=N3-1                                                        AFRUM  598
      C                                                                    AFRUM  599
      C     COMPUTE HYDROGRAPH ORDINATES AT EACH DT                        AFRUM  600
            S1=UP/T1                                                       AFRUM  601
            S2=(UR-UP)/(T2-T1)                                             AFRUM  602
            S3=(0.0-UR)/(T3-T2)                                            AFRUM  603
            HYDRO(1)=0.0                                                   AFRUM  604
            N1=N1+1                                                        AFRUM  605
            DO 150 I=2,N1                                                  AFRUM  606
            HYDRO(I)=HYDRO(I-1)+(S1*DT)                                    AFRUM  607
      150   CONTINUE                                                       AFRUM  608
            N1=N1+1                                                        AFRUM  609
            N2=N2+1                                                        AFRUM  610
            DO 160 I=N1,N2                                                 AFRUM  611
            HYDRO(I)=HYDRO(I-1)+(S2*DT)                                    AFRUM  612
      160   CONTINUE                                                       AFRUM  613
            N2=N2+1                                                        AFRUM  614
            N3=N3+1                                                        AFRUM  615
            DO 170 I=N2,N3                                                 AFRUM  616
            HYDRO(I)=HYDRO(I-1)+(S3*DT)                                    AFRUM  617
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  170 CONTINUE                                                       AFRUM  618
      HYDRO(N3)=0.0                                                  AFRUM  619
      WRITE(6,185)                                                   AFRUM  620
  185 FORMAT(////)                                                   AFRUM  621
C                                                                    AFRUM  622
C     CONVOLUTE HYDROGRAPH WITH EXCESS RAINFALL                      AFRUM  623
      ITOTAL=N3+NPRF-1                                               AFRUM  624
      IF (ITOTAL .LT. 800) GO TO 193                                 AFRUM  625
      WRITE(6,192)                                                   AFRUM  626
  192 FORMAT(/5X,"STORAGE SPACE EXCEEDED, KILL JOB")                 AFRUM  627
      ICRASH=1                                                       AFRUM  628
      GO TO 451                                                      AFRUM  629
  193 DO 194 I=1,N3                                                  AFRUM  630
      UHYDRO(I)=HYDRO(I)                                             AFRUM  631
  194 CONTINUE                                                       AFRUM  632
      DO 195 I=1,IDMAX                                               AFRUM  633
      HYDRO(I)=0.0                                                   AFRUM  634
  195 CONTINUE                                                       AFRUM  635
      DO 196 I=1,IDMAX                                               AFRUM  636
      RUNOFF(I)=0.0                                                  AFRUM  637
  196 CONTINUE                                                       AFRUM  638
      DO 197 I=1,N3                                                  AFRUM  639
      HYDRO(I)=UHYDRO(I)*PE(1)                                       AFRUM  640
  197 CONTINUE                                                       AFRUM  641
      DO 300 J=2,NPRF                                                AFRUM  642
      JMIN=J-1                                                       AFRUM  643
      JMAX=JMIN+N3                                                   AFRUM  644
      DO 200 JJ=1,JMIN                                               AFRUM  645
      RUNOFF(JJ)=0.0                                                 AFRUM  646
  200 CONTINUE                                                       AFRUM  647
      K=J                                                            AFRUM  648
      DO 210 JJ=K,JMAX                                               AFRUM  649
      RUNOFF(JJ)=UHYDRO(JJ-JMIN)*PE(K)                               AFRUM  650
  210 CONTINUE                                                       AFRUM  651
      DO 220 JJ=1,JMAX                                               AFRUM  652
      HYDRO(JJ)=HYDRO(JJ)+RUNOFF(JJ)                                 AFRUM  653
  220 CONTINUE                                                       AFRUM  654
  300 CONTINUE                                                       AFRUM  655
  310 CONTINUE                                                       AFRUM  656
      NBIG=ITOTAL                                                    AFRUM  657
      IF(NPRO .GT. NBIG) NBIG=NPRO                                   AFRUM  658
      BIGX=0.0                                                       AFRUM  659
      OBPEAK=0.0                                                     AFRUM  660
      PRPEAK=0.0                                                     AFRUM  661
      TPOB=0.0                                                       AFRUM  662
      TPPR=0.0                                                       AFRUM  663
      TIME(1)=0.0                                                    AFRUM  664
      HYDRO(1)=0.0                                                   AFRUM  665
      RNOFF(1)=0.0                                                   AFRUM  666
      DO 340 I=2,NBIG                                                AFRUM  667
      TIME(I)=TIME(I-1)+DT                                           AFRUM  668
  340 CONTINUE                                                       AFRUM  669
      IT1=ITOTAL+1                                                   AFRUM  670
      DO 350 I=IT1,IDMAX                                             AFRUM  671
      HYDRO(I)=0.0                                                   AFRUM  672
  350 CONTINUE                                                       AFRUM  673
      NPRO1=NPRO+1                                                   AFRUM  674
      DO 360 I=NPRO1,IDMAX                                           AFRUM  675
      RNOFF(I)=0.0                                                   AFRUM  676
  360 CONTINUE                                                       AFRUM  677
      IF (IUNIT .EQ. 0) GO TO 368                                    AFRUM  678
      CONVRT=(SQMI*640.*43560.)/(3600.*12.)                          AFRUM  679
      DO 365 I=1,NBIG                                                AFRUM  680
      HYDRO(I)=HYDRO(I)*CONVRT                                       AFRUM  681
      RNOFF(I)=RNOFF(I)*CONVRT                                       AFRUM  682
  365 CONTINUE                                                       AFRUM  683
  368 DO 410 I=1,NBIG                                                AFRUM  684
      IF (HYDRO(I) .GT. PRPEAK) GO TO 370                            AFRUM  685
      GO TO 380                                                      AFRUM  686
  370 PRPEAK=HYDRO(I)                                                AFRUM  687
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      TPPR=TIME(I)                                                      AFRUM  688
  380 CONTINUE                                                          AFRUM  689
      IF (RNOFF(I) .GT. OBPEAK) GO TO 385                               AFRUM  690
      GO TO 400                                                         AFRUM  691
  385 OBPEAK=RNOFF(I)                                                   AFRUM  692
      TPOB=TIME(I)                                                      AFRUM  693
  400 CONTINUE                                                          AFRUM  694
  410 CONTINUE                                                          AFRUM  695
      IF (ISIM .EQ. 1) OBPEAK=0.0                                       AFRUM  696
      IF (ISIM .EQ. 1) TPOB=0.0                                         AFRUM  697
      BIGY=PRPEAK                                                       AFRUM  698
      IF(OBPEAK .GT. BIGY) BIGY=OBPEAK                                  AFRUM  699
      GO TO 430                                                         AFRUM  700
 4109 CONTINUE                                                          AFRUM  701
      WRITE(6,411) TPOB,TPPR                                            AFRUM  702
  411 FORMAT(4X,"OBSERVED",10X,"PREDICTED"/                             AFRUM  703
     >2X,"TIME TO PEAK",5X,"TIME TO PEAK"/                              AFRUM  704
     >4X,"(HOURS)",10X,"(HOURS)"/                                       AFRUM  705
     >F10.3,F17.3)                                                      AFRUM  706
      IF (IUNIT .EQ. 1) GO TO 420                                       AFRUM  707
      WRITE(6,412) OBPEAK,PRPEAK                                        AFRUM  708
  412 FORMAT(//2X,"OBSERVED PEAK",5X,"PREDICTED PEAK"/                  AFRUM  709
     >5X,"(IN/HR)",11X,"(IN/HR)"/                                       AFRUM  710
     >F11.5,F19.5)                                                      AFRUM  711
      GO TO 4519                                                        AFRUM  712
  420 WRITE(6,425) OBPEAK,PRPEAK                                        AFRUM  713
  425 FORMAT(///2X,"OBSERVED PEAK",5X,"PREDICTED PEAK"/                 AFRUM  714
     >6X,"(CFS)",12X,"(CFS)",/                                          AFRUM  715
     >F11.5,F19.5)                                                      AFRUM  716
      GO TO 4519                                                        AFRUM  717
  430 BIGX=TIME(NBIG)                                                   AFRUM  718
      DUMX(1)=0.0                                                       AFRUM  719
      DUMX(2)=BIGX                                                      AFRUM  720
      DUMY(1)=0.0                                                       AFRUM  721
      DUMY(2)=BIGY                                                      AFRUM  722
      NPRF1=NBIG+1                                                      AFRUM  723
      NPRF2=NBIG+2                                                      AFRUM  724
       ARATE = "IN/HR"                                                  AFRUM  725
      IF (IUNIT .NE. 0) ARATE = "(CFS)"                                 AFRUM  726
      BRATE = 7HLBS/HR                                                  AFRUM  727
      IF (IUNIT .NE. 0) BRATE = 7HLBS/SEC                               AFRUM  728
      WRITE (6,4300)                                                    AFRUM  729
 4300 FORMAT(1H1,18X,"TABLE II.  HYDROGRAPH OUTPUT",///)                AFRUM  730
      IF (ILOAD .NE. 0) WRITE (6,434)                                   AFRUM  731
  434 FORMAT(1H+,52X,"SUSPENDED")                                       AFRUM  732
      WRITE (6,436)                                                     AFRUM  733
  436 FORMAT(7X,"OBSERVED",6X,"PREDICTED")                              AFRUM  734
      IF (ILOAD .NE. 0) WRITE (6,437)                                   AFRUM  735
  437 FORMAT(1H+,53X,"SOLIDS")                                          AFRUM  736
      WRITE (6,438)                                                     AFRUM  737
  438 FORMAT (6X,"FLOW OUT OF",3X,"FLOW OUT OF")                        AFRUM  738
      IF (ILOAD .NE. 0)  WRITE (6,439)                                  AFRUM  739
  439 FORMAT(1H+,51X,"DISCHARGED")                                      AFRUM  740
      WRITE (6,4391)                                                    AFRUM  741
 4391 FORMAT(6X,"WATERSHED",5X,"WATERSHED",8X,"TIME")                   AFRUM  742
      IF (ILOAD .NE. 0) WRITE (6,4392)                                  AFRUM  743
 4392 FORMAT(1H+,49X,"FROM WATERSHED")                                  AFRUM  744
      WRITE (6,4393) ARATE,ARATE                                        AFRUM  745
 4393 FORMAT(8X,A5,9X,A5,8X,"(HOURS)")                                  AFRUM  746
      IF (ILOAD .NE. 0) WRITE (6,4394) BRATE                            AFRUM  747
 4394 FORMAT(1H+,53X,A7)                                                AFRUM  748
      WRITE (6,4395)                                                    AFRUM  749
 4395 FORMAT (1H ,//)                                                   AFRUM  750
      IF(IUNIT.EQ.1) CONC=12./43560.                                    AFRUM  751
      IF(IUNIT.NE.1)CONC=SQMI*640.                                      AFRUM  752
      SUSS=0.0                                                          AFRUM  753
      DO 450 I=1,NBIG                                                   AFRUM  754
      WRITE(6,440) RNOFF(I),HYDRO(I),TIME(I)                            AFRUM  755
  440 FORMAT (3F14.3)                                                   AFRUM  756
      IF(ILOAD.EQ.0) GO TO 450                                          AFRUM  757
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      SUS=CONC*HYDRO(I)*DLOAD
      WRITE(6,441) SUS
441   FORMAT (1H+,44X,F15.3)
      IF(IUNIT.EQ.1) SUS=SUS*3600.
      SUSS=SUSS+SUS*DT
450   CONTINUE
451   CONTINUE
      VRO=SUSS/(CONC*DLOAD)
      IF(ILOAD.EQ.0) RETURN
      WRITE(6,460) SUSS
460   FORMAT (////,12X,"TOTAL SUSPENDED SOLIDS (LBS) DISCHARGED FROM WAT
     .ERSHED",/,12X,"DURING STORM EVENT = ",F15.3)
      IF(ICHAR.EQ.0) GO TO 760
      WRITE (6,4601)
4601  FORMAT (1H ,////)
      GO TO 4109
4519  CONTINUE
      IF(ICHAR.EQ.1) GO TO 760
      IF(ICHAR.NE.2) RETURN
      GO TO 780
760   ULFE=0.442*PI-0.568*U*PF+1.54
      CFE=4.42*ULFE
      LFE=ULFE*SRO(NPRF)*SQMI*640.
      ULMN=0.0072*PI-0.0092*U*PF+0.20
      CMN=4.42*ULMN
      LMN=ULMN*SRO(NPRF)*SQMI*640.
      ULCA=0.147*PI-0.189*U*PF+2.45
      CCA=4.42*ULCA
      LCA=ULCA*SRO(NPRF)*SQMI*640.
      ULMG=0.0597*PI-0.113*U*PF+0.0323
      CMG=4.42*ULMG
      LMG=ULMG*SRO(NPRF)*SQMI*640.
      ULSO=0.0719*PI-0.0216*U*PF+1.24
      CSO=4.42*ULSO
      LSO=ULSO*SRO(NPRF)*SQMI*640.
      ULAL=0.319*PI-0.128*U*PF+6.71
      CAL=4.42*ULAL
      LAL=ULAL*SRO(NPRF)*SQMI*640.
      GO TO 790
780   ULFE=0.323*PS+0.12
      CFE=4.42*ULFE
      LFE=ULFE*SRO(NPRF)*SQMI*640.
      ULMN=0.0161*PS+0.002
      CMN=4.42*ULMN
      LMN=ULMN*SRO(NPRF)*SQMI*640.
      ULCA=0.131*PS+0.38
      CCA=4.42*ULCA
      LCA=ULCA*SRO(NPRF)*SQMI*640.
      ULMG=0.133*PS+0.40
      CMG=4.42*ULMG
      LMG=ULMG*SRO(NPRF)*SQMI*640.
      ULSO=1.39*PS+2.45
      CSO=4.42*ULSO
      LSO=ULSO*SRO(NPRF)*SQMI*640.
      ULAL=0.19*PS+2.00
      CAL=4.42*ULAL
      LAL=ULAL*SRO(NPRF)*SQMI*640.
790   WRITE(6,791)CFE,LFE,CMN,LMN,CCA,LCA,CMG,LMG,CSO,LSO,CAL,LAL
791   FORMAT (//,12X,"FE CONC (PPM)",F15.5,/,12X,"FE LOAD (LBS)",F15.5,
     .        ///,12X,"MN CONC (PPM)",F15.5,/,12X,"MN LOAD (LBS)",F15.5,
     .        ///,12X,"CA CONC (PPM)",F15.5,/,12X,"CA LOAD (LBS)",F15.5,
     .        ///,12X,"MG CONC (PPM)",F15.5,/,12X,"MG LOAD (LBS)",F15.5,
     .        ///,12X,"SO4 CONC (PPM)",F14.5,/,12X,"SO4 LOAD (LBS)",
     .        F14.5,///,12X,"ALK CONC (PPM)",F15.5,/,12X,"ALK LOAD (LBS)"
     .        ,F15.5)
      RETURN
      END
```

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      C                                                                          AFRUM 1054
      C                                                                          AFRUM 1055
            SUBROUTINE BASINA(SQMI,PF,PS,BDATE,BASIN,PI)                         AFRUM 1056
      C                                                                          AFRUM 1057
      C                                                                          AFRUM 1058
            DIMENSION BASIN(4)                                                   AFRUM 1059
            WRITE(6,10) BASIN,BDATE,SQMI,PF,PS,PI                                AFRUM 1060
         10 FORMAT(46X,"THE WATERSHED NAME IS ",4A10,/,                          AFRUM 1061
           >36X,"THE DATE OF THE RAINFALL EVENT IS ",A8,/,                       AFRUM 1062
           >36X,"THE WATERSHED SIZE IN SQUARE MILES IS:        SQMI= ",F8.2/     AFRUM 1063
           >36X,"THE PERCENT OF THE BASIN WHICH IS FOREST IS:     PF= ",F8.2/    AFRUM 1064
           >36X,"THE PERCENT OF THE BASIN DENUDED IS:             PS= ",F8.2/    AFRUM 1065
           >36X,"THE PERCENT OF THE BASIN WHICH IS IMPERVIOUS IS: PI= ",F8.2/)   AFRUM 1066
            RETURN                                                               AFRUM 1067
            END                                                                  AFRUM 1068
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      C                                                                   AFRUM 1069
      C                                                                   AFRUM 1070
            SUBROUTINE ASSUME(ISIM,IPHI,IUNIT,IPLOT,ICHAR,ILAG,ILOAD)     AFRUM 1071
      C                                                                   AFRUM 1072
      C                                                                   AFRUM 1073
            IF(ISIM.EQ.1) GO TO 10                                        AFRUM 1074
            WRITE (6,5)                                                   AFRUM 1075
      5     FORMAT (46X,                                                  AFRUM 1076
           ."BY SETTING ISIM = 0 YOU HAVE INDICATED THAT YOU PLAN",/,     AFRUM 1077
           .36X,"TO SUPPLY EITHER ACTUAL OR DESIGN RAINFALL AND RUNOFF",/, AFRUM 1078
           .36X,"DATA; THEREFORE, THE SCS CURVE NUMBER, CN, WILL BE DE-",/, AFRUM 1079
           >36X,"TERMINED BY SETTING RUNOFF EQUAL TO PRECIPITATION EXCESS.",/) AFRUM 1080
            GO TO 12                                                      AFRUM 1081
         10 WRITE (6,15)                                                  AFRUM 1082
         15 FORMAT (46X,                                                  AFRUM 1083
           ."BY SETTING ISIM = 1 YOU HAVE INDICATED THAT YOU PLAN",/,     AFRUM 1084
           >36X,"TO SUPPLY ACTUAL OR DESIGN RAINFALL DATA; THEREFORE, AN",/, AFRUM 1085
           >36X,"ESTIMATE OF THE SCS CURVE NUMBER, CN, MUST BE PROVIDED.",/) AFRUM 1086
         12 CONTINUE                                                      AFRUM 1087
            IF(IUNIT.EQ.1) GO TO 25                                       AFRUM 1088
            WRITE(6,20)                                                   AFRUM 1089
         20 FORMAT(46X,"OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS",/, AFRUM 1090
           >36X,"AND INCHES AS SELECTED BY SETTING IUNIT = 0.",/)         AFRUM 1091
            GO TO 32                                                      AFRUM 1092
         25 WRITE(6,30)                                                   AFRUM 1093
         30 FORMAT(46X,"OUTPUT UNITS OF THE SIMULATED HYDROGRAPH ARE HOURS",/, AFRUM 1094
           >36X,"AND CUBIC FEET PER SECOND, CFS, AS SELECTED BY SETTING",/, AFRUM 1095
           >36X,"IUNIT = 1.",/)                                           AFRUM 1096
         32 CONTINUE                                                      AFRUM 1097
            IF(IPLOT.EQ.1) GO TO 40                                       AFRUM 1098
            WRITE(6,35)                                                   AFRUM 1099
         35 FORMAT(46X,"NO PLOT HAS BEEN REQUESTED; IPLOT = 0.",/)        AFRUM 1100
            GO TO 47                                                      AFRUM 1101
         40 WRITE(6,45)                                                   AFRUM 1102
         45 FORMAT(46X,"YOU HAVE REQUESTED THAT THE HYDROGRAPH BE PLOTTED",/, AFRUM 1103
           >36X,"BY SETTING IPLOT = 1.",/)                                AFRUM 1104
         47 CONTINUE                                                      AFRUM 1105
            IF(ICHAR.GT.0) GO TO 55                                       AFRUM 1106
            WRITE(6,50)                                                   AFRUM 1107
         50 FORMAT(46X,"THE WATERSHED IS ASSUMED TO BE URBAN WITHOUT",/,  AFRUM 1108
           >36X,"STORM SEWERS; ICHAR = 0.",/)                             AFRUM 1109
            GO TO 100                                                     AFRUM 1110
         55 IF(ICHAR.GT.1) GO TO 65                                       AFRUM 1111
            WRITE(6,60)                                                   AFRUM 1112
         60 FORMAT(46X,"THE WATERSHED IS ASSUMED TO BE URBAN WITH STORM",/, AFRUM 1113
           >36X,"SEWERS; ICHAR = 1.",/)                                   AFRUM 1114
            GO TO 100                                                     AFRUM 1115
         65 IF(ICHAR.GT.2) GO TO 75                                       AFRUM 1116
            WRITE(6,70)                                                   AFRUM 1117
         70 FORMAT(46X,"THE WATERSHED IS SIMILAR TO A COAL STRIP MINE",/, AFRUM 1118
           >36X,"AREA, OR DENUDED FOREST AREA; ICHAR = 2."/)              AFRUM 1119
            GO TO 100                                                     AFRUM 1120
         75 IF(ICHAR.GT.3) GO TO 85                                       AFRUM 1121
            WRITE(6,80)                                                   AFRUM 1122
         80 FORMAT(46X,"THE WATERSHED IS MOSTLY AGRICULTURAL; ICHAR = 3X",/) AFRUM 1123
            GO TO 100                                                     AFRUM 1124
         85 WRITE(6,90)                                                   AFRUM 1125
         90 FORMAT(46X,"THE WATERSHED IS ASSUMED TO BE MOSTLY FORESTED;",/, AFRUM 1126
           >36X,"YOU HAVE SET ICHAR = 4."/)                               AFRUM 1127
        100 CONTINUE                                                      AFRUM 1128
            IF(ILAG.GT.0) GO TO 110                                       AFRUM 1129
            WRITE(6,105)                                                  AFRUM 1130
        105 FORMAT(46X,"YOU HAVE DECIDED TO SELECT A VALUE FOR LAG",/,    AFRUM 1131
           >36X,"MODULUS IN HOURS; ILAG = 0."/  )                         AFRUM 1132
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      GO TO 130                                                        AFRUM 1133
  110 IF(ILAG.GT.1) GO TO 120                                          AFRUM 1134
      WRITE(6,115)                                                     AFRUM 1135
  115 FORMAT(46X,"YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN",/,      AFRUM 1136
     >36X,"HOURS ASSUMING IT IS A FUNCTION OF THE WATERSHED AREA",/,   AFRUM 1137
     >36X,"AND PERCENT IMPERVIOUS AREA OF THE WATERSHED; ILAG = 1.",/) AFRUM 1138
      GO TO 130                                                        AFRUM 1139
  120 WRITE(6,125)                                                     AFRUM 1140
  125 FORMAT(46X,"YOU HAVE ELECTED TO SIMULATE LAG MODULUS IN",/,      AFRUM 1141
     >36X,"HOURS ASSUMING IT IS A FUNCTION OF THE RURAL WATERSHED",/,  AFRUM 1142
     >36X,"AREA AND THE PERCENT OF THE WATERSHED THAT IS FORESTED;",/, AFRUM 1143
     >36X,"ILAG = 2."/)                                                AFRUM 1144
  130 CONTINUE                                                         AFRUM 1145
      IF(ILOAD.EQ.2) GO TO 140                                         AFRUM 1146
      WRITE(6,135)                                                     AFRUM 1147
  135 FORMAT(46X,"SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE",/,    AFRUM 1148
     >36X,"WATERSHED IS RURAL OR URBAN WITHOUT MAJOR CONSTRUCTION;",/, AFRUM 1149
     >36X,"ILOAD = 1.",/)                                              AFRUM 1150
      GO TO 150                                                        AFRUM 1151
  140 WRITE(6,145)                                                     AFRUM 1152
  145 FORMAT(46X,"SEDIMENT LOAD HAS BEEN SIMULATED ASSUMING THE",/,    AFRUM 1153
     >36X,"WATERSHED IS A DENUDED FOREST AREA OR A COAL STRIP MINE",/, AFRUM 1154
     >36X,"AREA; ILOAD = 2.",////)                                     AFRUM 1155
 150  CONTINUE                                                         AFRUM 1156
      WRITE (6,160)                                                    AFRUM 1157
 160  FORMAT (1H1)                                                     AFRUM 1158
      RETURN                                                           AFRUM 1159
      END                                                              AFRUM 1160
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      C                                                                        AFRUM 1161
      C                                                                        AFRUM 1162
            SUBROUTINE AFSOP                                                   AFRUM 1163
      C                                                                        AFRUM 1164
      C                                                                        AFRUM 1165
            WRITE (6,1000)                                                     AFRUM 1166
       1000 FORMAT(15(/),63X,"INTRODUCTION",///,35X,                           AFRUM 1167
           . "THE U.S. AIR FORCE RUNOFF MODEL (AFRUM) FOR SIMULATING STORM",/, AFRUM 1168
           . 35X,"HYDROGRAPHS AND POLLUTANT YIELDS WAS DEVELOPED FOR THE AIR F AFRUM 1169
           .ORCE"/, 35X,                                                       AFRUM 1170
           ."BY THE DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF TENNESSEE," AFRUM 1171
           . /, 35X,                                                           AFRUM 1172
           . "KNOXVILLE AND THE RESEARCH AND DEVELOPMENT DIRECTORATE OF THE",  AFRUM 1173
           . /,35X,                                                            AFRUM 1174
           ."AIR FORCE ENGINEERING SERVICES CENTER (AFESC), TYNDALL AIR FORCE" AFRUM 1175
           .,/,35X,                                                            AFRUM 1176
           ."BASE, FLORIDA.  DR. DONALD E. OVERTON OF THE UNIVERSITY OF TENNES AFRUM 1177
           .-"/,35X,"SEE WAS THE PRINCIPAL INVESTIGATOR AND  DR. GEORGE W. SCH AFRUM 1178
           .LOSSNAGLE"/,35X,"OF THE U.S. AIR FORCE WAS THE PROJECT OFFICER.    AFRUM 1179
           .THE RESULTS OF THREE")                                             AFRUM 1180
            WRITE (6,2000)                                                     AFRUM 1181
       2000 FORMAT(1H ,34X,"SEPARATE BUT COMPLIMENTARY STUDIES WERE INCORPORAT AFRUM 1182
           .ED INTO AFRUM.",/,35X,                                             AFRUM 1183
           ."EACH OF THE THREE STUDIES HAD THE FUNDAMENTAL OBJECTIVE TO EVALUA AFRUM 1184
           .TE" ,/,35X,"THE EFFECTS OF SPECIALIZED LAND USE ON STORMWATER RUNO AFRUM 1185
           .FF AND ITS",/,35X,                                                 AFRUM 1186
           ."ASSOCIATED QUALITY. THE THREE STUDIES WERE FUNDED BY THE U.S. DEP AFRUM 1187
           .ART-",/,35X,                                                       AFRUM 1188
           ."MENT OF ENERGY, THE U.S. DEPARTMENT OF INTERIOR AND THE U.S. AIR  AFRUM 1189
           .FORCE.",/,35X,                                                     AFRUM 1190
           ."THE STUDY PERIOD WAS FROM 1975 THROUGH 1979.  AFRUM WAS DEVEL-",  AFRUM 1191
           . /,35X ,                                                           AFRUM 1192
           ."OPED IN THE COURSE OF ANALYZING 410 STORM EVENTS ON 36 WATERSHEDS AFRUM 1193
           .,",/,35X,                                                          AFRUM 1194
           . "WHICH INCLUDED AGRICULTURAL, URBAN AND FORESTED LAND USE CONDITI AFRUM 1195
           .IONS",/,35X,                                                       AFRUM 1196
           ."AS WELL AS COAL STRIP MINING AND THREE WATERSHEDS ON A U.S. AIR F AFRUM 1197
           .ORCE",/,35X,"BASE.",//)                                            AFRUM 1198
            WRITE (6,3000)                                                     AFRUM 1199
       3000 FORMAT (1H ,34X,                                                   AFRUM 1200
           ."AFRUM WAS DEVELOPED FOR THE PURPOSE OF SIMULATING STORMWATER",/,  AFRUM 1201
           .35X,"HYDROGRAPHS FROM ACTUAL OR DESIGN STORM RAINFALL DISTRIBUTION AFRUM 1202
           .S,",/,35X,                                                         AFRUM 1203
           ."LAND USE CHARACTERISTICS AND SOIL TYPE IN THE WATERSHED OF CONCER AFRUM 1204
           .N.",/,35X,                                                         AFRUM 1205
           ."THE REQUIRED INPUT BASIN CHARACTERISTICS ARE:",/,                 AFRUM 1206
           >35X,"     1.  PERCENT OF WATERSHED THAT IS FORESTED"/,             AFRUM 1207
           >35X,"     2.  PERCENT OF WATERSHED THAT IS IMPERVIOUS"/,           AFRUM 1208
           .35X,"     3.  PERCENT OF WATERSHED THAT IS DENUDED OR STRIP MINED" AFRUM 1209
           .,/,35X,"     4.  SURFACE DRAINAGE AREA",/,35X,                     AFRUM 1210
           ."RUNOFF VOLUME AND THE ASSOCIATED RAINFALL EXCESS TIME DISTRIBUTIO AFRUM 1211
           .N",/,35X,                                                          AFRUM 1212
           ."ARE SIMULATED FROM INPUT RAINFALL USING  THE U.S. SOIL CONSERVATI AFRUM 1213
           .ON")                                                               AFRUM 1214
            WRITE (6,4000)                                                     AFRUM 1215
       4000 FORMAT (1H ,34X,                                                   AFRUM 1216
           ."SERVICE CURVE NUMBER.  IF A RUNOFF HYDROGRAPH IS PROVIDED WITH TH AFRUM 1217
           .E",/,35X,                                                          AFRUM 1218
           ."ASSOCIATED RAINFALL HYETOGRAPH, AFRUM WILL COMPUTE THE CURVE NUM- AFRUM 1219
           .",/,35X,                                                           AFRUM 1220
           ."BER, CN; OTHERWISE  CN MUST BE AN INPUT.  CN IS SELECTED BY USING AFRUM 1221
           .",/,35X,                                                           AFRUM 1222
           ."THE PROCEDURES PROVIDED IN THE NATIONAL ENGINEERING HANDBOOK,",/, AFRUM 1223
           .35X, "SECTION 4, U.S. SOIL CONSERVATION SERVICE.",///,             AFRUM 1224
           .35X,"AFRUM MAKES PROVISION FOR SIMULATING A UNIT HYDROGRAPH OR",/, AFRUM 1225
           .35X,"UNIT RESPONSE FUNCTION, WHICH IS CONVOLUTED WITH THE RAINFALL AFRUM 1226
           . EX-",/,35X,                                                       AFRUM 1227
           ."CESS HYETOGRAPH.  AFRUM ALSO SIMULATES POLLUTANT LOADS FOR THE"/, AFRUM 1228
           .35X,                                                               AFRUM 1229
           ."INPUTED STORM. THIS SIMULATION IS A FUNCTION OF THE SPECIFIED",/, AFRUM 1230
           >35X,"WATERSHED AND STORM CHARACTERISTICS.",/,1H1)                  AFRUM 1231
            RETURN                                                             AFRUM 1232
            END                                                                AFRUM 1233
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      C                                                                    AFRUM  825
      C                                                                    AFRUM  826
            SUBROUTINE HYPLOT                                              AFRUM  827
      C                                                                    AFRUM  828
      C                                                                    AFRUM  829
            REAL KT1,KT2,KUP,IMP,LOSS,KT23,KUR                             AFRUM  830
            COMMON RUNOFF(800),HYDRO(800),RNOFF(500),RAIN(500),STAGE(500)  AFRUM  831
           >,ARF(500),RF(500),PEI(500),PE(500),SRO(500),BASIN(4),BDATE,    AFRUM  832
           >IAREA(664),PHI,DT,U,T1,T2,T3,UP,UR,REI,KT1,KT2,KUP,RN,ITOTAL,  AFRUM  833
           >ICRASH,IDMAX,NPRF,UHYDRO(800),NPRO,CNOPT,NBIG,TL,KT23          AFRUM  834
           >,TIME(500),TFLOW(500),TFLOWI(500),SFLOW(500),BSFLOW(500)       AFRUM  835
           >,DUMX(4),DUMY(4),BIGX,OBPEAK,PRPEAK,TPOB,TPPR,ISIM             AFRUM  836
           >,IPLOT,IUNIT,NPRF1,NPRF2,AREA,KUR                              AFRUM  837
           >,TITLE(20),SQMI,SHAPE,SC,DD,SINU,CNA,SS,IMP,TLP                AFRUM  838
           <,ILOAD,DLOAD                                                   AFRUM  839
            DIMENSION X(2),Y(2)                                            AFRUM  840
            CALL SCALE(DUMX, 7.5,2,1)                                      AFRUM  841
            CALL SCALE(DUMY,4.5,2,1)                                       AFRUM  842
            TIME(NPRF1)=DUMX(3)                                            AFRUM  843
            TIME(NPRF2)=DUMX(4)                                            AFRUM  844
            HYDRO(NPRF1)=DUMY(3)                                           AFRUM  845
            HYDRO(NPRF2)=DUMY(4)                                           AFRUM  846
            RNOFF(NPRF1)=DUMY(3)                                           AFRUM  847
            RNOFF(NPRF2)=DUMY(4)                                           AFRUM  848
            CALL AXIS(0.0,0.0,1H ,-1,7.5,0.0,TIME(NPRF1),TIME(NPRF2))      AFRUM  849
            CALL SYMBOL(1.0,-1.0,.14," TIME FROM BEGINNING OF STORM (HOURS) ",  AFRUM  850
           .   0.0,38)                                                     AFRUM  851
            IF(IUNIT .EQ. 1) GO TO 50                                      AFRUM  852
            CALL AXIS(0.0,0.0,1H ,1,4.5,90.0,HYDRO(NPRF1),HYDRO(NPRF2))    AFRUM  853
            GO TO 51                                                       AFRUM  854
      50    CALL AXIS(0.0,0.0,1H ,1,4.5,90.0,HYDRO(NPRF1),HYDRO(NPRF2))    AFRUM  855
      51    CONTINUE                                                       AFRUM  856
            CALL SYMBOL(-.8,1.5,.14," RUNOFF ",90.,8)                      AFRUM  857
            IF (IUNIT.EQ.0) CALL SYMBOL(-.8,2.7,.14,"IN/HR",90.,5)         AFRUM  858
            IF (IUNIT.EQ.1) CALL SYMBOL(-.8,2.7,.14,"(CFS)",90.,5)         AFRUM  859
            IF (ISIM .EQ. 1) GO TO 52                                      AFRUM  860
            CALL LINE (TIME,RNOFF,NBIG,1,1,2)                              AFRUM  861
      52    CALL PLOT(0.0,0.0,3)                                           AFRUM  862
            CALL LINE(TIME,HYDRO,NBIG,1,0,0)                               AFRUM  863
            CALL SYMBOL(.65,4.75,0.14,BASIN,0.0,40)                        AFRUM  864
            CALL SYMBOL(1.0,4.5,0.14,BDATE,0.0,8)                          AFRUM  865
            IF (ISIM .EQ. 1) GO TO 54                                      AFRUM  866
            CALL SYMBOL (5.0,4.5,.1,"OBSERVED HYDROGRAPH",0.0,19)          AFRUM  867
      54    CALL SYMBOL( 5.0,4.15,.10,"U=  ",0.0,4)                        AFRUM  868
            CALL NUMBER(999.0,999.0,.10,U    ,0.0,3)                       AFRUM  869
            CALL SYMBOL( 5.0,4.00,.10,"N=  ",0.0,4)                        AFRUM  870
            CALL NUMBER(999.0,999.0,.10,RN   ,0.0,3)                       AFRUM  871
            CALL SYMBOL( 5.0,3.85,.10,"REI=",0.0,4)                        AFRUM  872
            CALL NUMBER(999.0,999.0,.10,REI  ,0.0,3)                       AFRUM  873
            CALL SYMBOL( 5.0,3.70,.10,"TL= ",0.0,4)                        AFRUM  874
            CALL NUMBER(999.0,999.0,.10,TL   ,0.0,3)                       AFRUM  875
            CALL SYMBOL( 5.0,3.55,.10,"CN= ",0.0,4)                        AFRUM  876
            CALL NUMBER(999.0,999.0,.10,CNOPT,0.0,2)                       AFRUM  877
            CALL PLOT(0.0,0.0,3)                                           AFRUM  878
            X(1)=7.0                                                       AFRUM  879
            X(2)=7.6                                                       AFRUM  880
            IF (ISIM .EQ. 1) GO TO 56                                      AFRUM  881
            YY = 4.55                                                      AFRUM  882
            XX = 7.1                                                       AFRUM  883
            DO 60 I = 1,16                                                 AFRUM  884
            CALL SYMBOL (XX,YY,.07,2,0.0,-1)                               AFRUM  885
      60    XX = XX + .04                                                  AFRUM  886
      56    Y(1) = 4.35                                                    AFRUM  887
            Y(2) = Y(1)                                                    AFRUM  888
            CALL SYMBOL (5.0,4.3,.1,"PREDICTED HYDROGRAPH",0.0,20)         AFRUM  889
            CALL PLOT (X(1),Y(1),3)                                        AFRUM  890
            CALL PLOT (X(2),Y(2),2)                                        AFRUM  891
            CALL PLOT(0.0,0.0,3)                                           AFRUM  892
            IF (ISIM .EQ  1) GO TO 70                                      AFRUM  893
      70    CONTINUE                                                       AFRUM  894
            RETURN                                                         AFRUM  895
            END                                                            AFRUM  896
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      C                                                          AFRUM  897
      C                                                          AFRUM  898
            SUBROUTINE LETTER                                    AFRUM  899
      C                                                          AFRUM  900
      C                                                          AFRUM  901
            DIMENSION ITITLE(12)                                 AFRUM  902
            WRITE(6,6001)                                        AFRUM  903
            DO 1000 L=1,4                                        AFRUM  904
            READ(5,100)(ITITLE(I),I=1,12)                        AFRUM  905
      100   FORMAT(12A1)                                         AFRUM  906
      6001  FORMAT(1H1)                                          AFRUM  907
      6002  FORMAT(1H-)                                          AFRUM  908
            CALL CHARAC(ITITLE)                                  AFRUM  909
            WRITE(6,6002)                                        AFRUM  910
      1000  CONTINUE                                             AFRUM  911
      9000  CONTINUE                                             AFRUM  912
            WRITE(6,6001)                                        AFRUM  913
            RETURN                                               AFRUM  914
            END                                                  AFRUM  915
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      C                                                                 AFRUM  916
      C                                                                 AFRUM  917
            SUBROUTINE CHARAC(ITITLE)                                   AFRUM  918
      C                                                                 AFRUM  919
      C                                                                 AFRUM  920
             DIMENSION ICHAR(37,12),IALPHA(37),ID(12),ITITLE(12),MASK(11),AFRUM  921
           .LINE1(135)                                                  AFRUM  922
            INTEGER OFFSET                                              AFRUM  923
            DATA(ICHAR(01,K),K=1,12)/                                   AFRUM  924
           .0160B,0370B,0614B,1406B,1406B,1406B,1776B,1776B,1406B,1406B,AFRUM  925
           .1406B,1406B/                                                AFRUM  926
            DATA(ICHAR(2,K),K=1,12)/                                    AFRUM  927
           .1770B,1774B,1406B,1406B,1406B,1774B,1774B,1406B,1406B,1406B,AFRUM  928
           .1774B,1770B/                                                AFRUM  929
            DATA(ICHAR(03,K),K=1,12)/                                   AFRUM  930
           .0376B,0776B,1600B,1400B,1400B,1400B,1400B,1400B,1400B,1600B,AFRUM  931
           .0776B,0376B/                                                AFRUM  932
            DATA(ICHAR(04,K),K=1,12)/                                   AFRUM  933
           .1770B,1774B,1416B,1406B,1406B,1406B,1406B,1406B,1406B,1416B,AFRUM  934
           .1774B,1770B/                                                AFRUM  935
            DATA(ICHAR(05,K),K=1,12)/                                   AFRUM  936
           .2*1776B,3*1400B,2*1774B,3*1400B,2*1776B/                    AFRUM  937
            DATA(ICHAR(06,K),K=1,12)/                                   AFRUM  938
           .2*1776B,3*1400B,2*1774B,5*1400B/                            AFRUM  939
            DATA(ICHAR(07,K),K=1,12)/                                   AFRUM  940
           .0376B,0776B,3*1400B,1434B,1476B,3*1406B,0776B,0374B/        AFRUM  941
            DATA(ICHAR(08,K),K=1,12)/                                   AFRUM  942
           .1406B,1406B,1406B,1406B,1406B,1776B,1776B,1406B,1406B,1406B,AFRUM  943
           .1406B,1406B/                                                AFRUM  944
            DATA(ICHAR(09,K),K=1,12)/                                   AFRUM  945
           .1776B,1776B,0160B,0160B,0160B,0160B,0160B,0160B,0160B,0160B,AFRUM  946
           .1776B,1776B/                                                AFRUM  947
            DATA(ICHAR(10,K),K=1,12)/                                   AFRUM  948
           .0176B,0176B,6*0030B,2*1430B,1770B,0760B/                    AFRUM  949
            DATA(ICHAR(11,K),K=1,12)/                                   AFRUM  950
           .1406B,1414B,1430B,1460B,1540B,2*1700B,1540B,1460B,1430B,1414B,AFRUM  951
           .1406B/                                                      AFRUM  952
            DATA(ICHAR(12,K),K=1,12)/                                   AFRUM  953
           .10*1400B,2*1776B/                                           AFRUM  954
            DATA(ICHAR(13,K),K=1,12)/                                   AFRUM  955
           .1406B,1616B,1736B,2*1566B,1446B,6*1406B/                    AFRUM  956
            DATA(ICHAR(14,K),K=1,12)/                                   AFRUM  957
           .1406B,1406B,1606B,1706B,2*1546B,2*1466B,1436B,1416B,1406B,1406B/AFRUM  958
            DATA(ICHAR(15,K),K=1,12)/                                   AFRUM  959
           .0370B,0774B,8*1406B,0774B,0370B/                            AFRUM  960
            DATA(ICHAR(16,K),K=1,12)/                                   AFRUM  961
           .1770B,1774B,2*1406B,1774B,1770B,6*1400B/                    AFRUM  962
            DATA(ICHAR(17,K),K=1,12)/                                   AFRUM  963
           .0370B,0774B,6*1406B,1466B,1436B,0774B,0370B/                AFRUM  964
            DATA(ICHAR(18,K),K=1,12)/                                   AFRUM  965
           .1770B,1774B,2*1406B,1774B,1770B,1540B,1460B,1430B,1414B,2*1406B/AFRUM  966
            DATA(ICHAR(19,K),K=1,12)/                                   AFRUM  967
           .0376B,0776B,3*1400B,0770B,0374B,3*0006B,1774B,1770B/        AFRUM  968
            DATA(ICHAR(20,K),K=1,12)/                                   AFRUM  969
           .2*1776B,10*0160B/                                           AFRUM  970
            DATA(ICHAR(21,K),K=1,12)/                                   AFRUM  971
           .10*1406B,0774B,0370B/                                       AFRUM  972
            DATA(ICHAR(22,K),K=1,12)/                                   AFRUM  973
           .7*1406B,2*0614B,0330B,0160B,0040B/                          AFRUM  974
            DATA(ICHAR(23,K),K=1,12)/                                   AFRUM  975
           .6*1406B,1446B,2*1566B,1736B,1616B,1406B/                    AFRUM  976
            DATA(ICHAR(24,K),K=1,12)/                                   AFRUM  977
           .2*1406B,0614B,0330B,4*0160B,0330B,0614B,2*1406B/            AFRUM  978
            DATA(ICHAR(25,K),K=1,12)/                                   AFRUM  979
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      .3*1406B,2*0614B,0330B,6*0160B/                                       AFRUM  980
       DATA(ICHAR(26,K),K=1,12)/                                            AFRUM  981
      .2*1776B,0006B,0014B,0030B,0060B,0140B,0300B,0600B,1400B,2*1776B/     AFRUM  982
       DATA(ICHAR(27,K),K=1,12)/                                            AFRUM  983
      .12*0/                                                                AFRUM  984
       DATA(ICHAR(28,K),K=1,12)/                                            AFRUM  985
      .2*1776B,8*1406B,2*1776B/                                             AFRUM  986
       DATA(ICHAR(29,K),K=1,12)/                                            AFRUM  987
      .0060B,0160B,0360B,7*0060B,2*0776B/                                   AFRUM  988
       DATA(ICHAR(30,K),K=1,12)/                                            AFRUM  989
      .2*1774P,3*0014B,0030B,0060B,0140B,0300B,0600C,2*1776B/               AFRUM  990
       DATA(ICHAR(31,K),K=1,12)/                                            AFRUM  991
      .2*1776B,3*0006B,2*0376B,3*0006B,2*1776B/                             AFRUM  992
       DATA(ICHAR(32,K),K=1,12)/                                            AFRUM  993
      .0016B,0036B,0066B,0146B,0306B,0776B,1776B,5*0006B/                   AFRUM  994
       DATA(ICHAR(33,K),K=1,12)/                                            AFRUM  995
      .2*1776B,2*1400B,2*1776B,4*0006B,2*1776B/                             AFRUM  996
       DATA(ICHAR(34,K),K=1,12)/                                            AFRUM  997
      .2*1776B,3*1400B,2*1776B,3*1406B,2*1776B/                             AFRUM  998
       DATA(ICHAR(35,K),K=1,12)/                                            AFRUM  999
      .2*1776B,2*0006B,0014B,2*0030B,5*0060B/                               AFRUM 1000
       DATA(ICHAR(36,K),K=1,12)/                                            AFRUM 1001
      .2*1776B,3*1406B,2*1776B,3*1406B,2*1776B/                             AFRUM 1002
       DATA(ICHAR(37,K),K=1,12)/                                            AFRUM 1003
      .2*1776B,3*1406B,2*1776B,3*0006B,2*1776B/                             AFRUM 1004
       DATA IALPHA/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,     AFRUM 1005
      .1HN,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1H ,1H0,1H1,     AFRUM 1006
      .1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/                                     AFRUM 1007
       DATA LINE1/135*1H /                                                  AFRUM 1008
       DATA MASK/2000B,1000B,400B,200B,100B,40B,20B,10B,4B,2B,1B/           AFRUM 1009
       DO 150 IJ=1,12                                                       AFRUM 1010
       J= 13-IJ                                                             AFRUM 1011
       IF(ITITLE(J).NE.IALPHA(27)) GO TO 70                                 AFRUM 1012
  150  CONTINUE                                                             AFRUM 1013
   70  CONTINUE                                                             AFRUM 1014
       NUMLET=J                                                             AFRUM 1015
       OFFSET=(12-NUMLET)*6                                                 AFRUM 1016
       DO 250 LJ=1,12                                                       AFRUM 1017
       ITEST=0                                                              AFRUM 1018
       DO 251 JK=1,37                                                       AFRUM 1019
       IF(ITITLE(LJ).EQ.IALPHA(JK)) ITEST=1                                 AFRUM 1020
       IF(ITEST.EQ.0) GO TO 251                                             AFRUM 1021
       ID(LJ)=JK                                                            AFRUM 1022
       GO TO 250                                                            AFRUM 1023
  251  CONTINUE                                                             AFRUM 1024
       ID(LJ)= 27                                                           AFRUM 1025
  250  CONTINUE                                                             AFRUM 1026
       DO 2000 LNCNT=1,12                                                   AFRUM 1027
       DO 1000 LPOS=1,12                                                    AFRUM 1028
       IPOS=(11*(LPOS-1))+ OFFSET                                           AFRUM 1029
       DO 1200 MAKEUP=1,11                                                  AFRUM 1030
       LTEST=ICHAR(ID(LPOS),LNCNT).AND.MASK(MAKEUP)                         AFRUM 1031
       IF(LTEST.EQ.0) GO TO 1200                                            AFRUM 1032
       LINE1(IPOS+MAKEUP)=1HO                                               AFRUM 1033
 1200  CONTINUE                                                             AFRUM 1034
 1000  CONTINUE                                                             AFRUM 1035
       WRITE(6,200)(LINE1(JQ),JQ=1,135)                                     AFRUM 1036
       DO 600 IK=1,135                                                      AFRUM 1037
  600  IF(LINE1(IK).EQ.1HO) LINE1(IK)=1HX                                   AFRUM 1038
       WRITE(6,201)(LINE1(JQ),JQ=1,135)                                     AFRUM 1039
       DO 601 IK=1,135                                                      AFRUM 1040
  601  IF(LINE1(IK).EQ.1HX) LINE1(IK)=1HA                                   AFRUM 1041
       WRITE(6,201)(LINE1(JQ),JQ=1,135)                                     AFRUM 1042
       DO 602 IK=1,135                                                      AFRUM 1043
  602  IF(LINE1(IK).EQ.1HA)LINE1(IK)=1HV                                    AFRUM 1044
       WRITE(6,201) (LINE1(JQ),JQ=1,135)                                    AFRUM 1045
  201  FORMAT(1H+,135A1)                                                    AFRUM 1046
  200  FORMAT(1H ,135A1)                                                    AFRUM 1047
       DO 106 I=1,135                                                       AFRUM 1048
       LINE1(I)=1H                                                          AFRUM 1049
  106  CONTINUE                                                             AFRUM 1050
 2000  CONTINUE                                                             AFRUM 1051
       RETURN                                                               AFRUM 1052
       END                                                                  AFRUM 1053
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